APPENDIX A

Environmental Documentation

Appendix A:
Supplemental Environmental Information

List of Contents:

Compliance of the Proposed Action with Environmental Protection Statutes and Other Environmental Requirements

Federal Statutes	Level of Compliance
Archaeological and Historic Preservation Act	Full
Clean Air Act	Full
Clean Water Act	Full
Comprehensive Environmental Response, Compensation and Liability Act	Full
Endangered Species Act	Full
Estuary Protection Act	Full
Farmland Protection Policy Act	N/A
Federal Water Project Recreation Act	Full
Fish and Wildlife Coordination Act	Full
Land and Water Conservation Act Fund	Full
National Environmental Policy Act	Full
National Historic Preservation Act	Full
North American Wetlands Conservation Act	Full
Resource Conservation and Recovery Act	Full
Rivers and Harbors Act	Full
Water Resources Development Acts	Full
Water Resources Planning Act	Full
Watershed Protection and Flood Prevention Act	Full
Wild and Scenic Rivers Act	N/A
Wilderness Act	Full

Executive Orders, Memoranda, etc.	
Protection and Enhancement of Environmental Quality (E.O.11514)	Full
Protection and Enhancement of Cultural Environment (E.O.11593)	Full
Floodplain Management (E.O.11988)	Full
Protection of Wetlands (E.O.11990)	Full
Prime and Unique Farmlands (CEQ Memorandum, 11 Aug. 80)	Full
Environmental Justice (E.O.12898)	Full
Recreational Fisheries (E.O. 12962)	Full

COMPLIANCE LEVEL DEFINITIONS:

a. Full Compliance (Full): Having met all requirements of the Statute, E.O., or other environmental requirements for the current stage of planning.
b. Partial Compliance (P/C): Not having met some of the requirements that normally are met in the current stage of planning.
c. Non-Compliance (N/C): Violation of a requirement of the Statute, E.O., or other environmental requirements.
d. Not Applicable (N/A): No requirements for the Statute, E.O., or other environmental requirements for the current stage of planning.

ANNEX A

CLEAN WATER ACT
SECTION 404(b)(1) EVALUATION
SMITH ISLAND RESTORATION AND PROTECTION PROJECT, MARYLAND

I. Project Description

a. Location

The project area is located off-shore of Martin Wildlife Refuge, the northern section of Smith Island, Maryland. Smith Island is located on the west side of the Tangier Sound and west of the town of Crisfield, in Somerset County, Maryland. Smith Island is located at approximately 37° 58’ 00’’ degrees latitude and 76° 02’ 00’’ degrees longitude. The area is shown on the U.S. Geological Survey Kedges Strait 7.5' quadrangle topographic maps.

b. General Description

The proposed project will involve shoreline protection for the western shoreline and northern coves of Martin Wildlife Refuge. The shoreline stabilization plan consists of the constructing approximately 19,270, linear feet of segmented breakwaters, constructed of stone, approximately 30 feet to 100 feet channelward of the existing shoreline. In addition, the projects consists of the 26 acres of wetland creation, using 61,600 cubic yards of material.

c. Purpose

The proposed actions are designed to protect and restore the submerged aquatic vegetation (SAV) beds surrounding Smith Island and offset severe shoreline erosion occurring throughout Martin Wildlife Refuge, located on Smith Island, Maryland. At present, Smith Island is eroding at between 8 and 12 feet per year, leading to significant loss of marsh, damaging SAV beds, and contributing excessive sediments to the Bay. The erosion is a result of increased wave energy and marsh breaching, exposing interior areas to additional erosion. Shoreline stabilization is required to protect the ecology of the island from future damage and protect the integrity of a valuable ecosystem.

d. General Description of Discharge Material

(1) *Characteristics of Fill Material* - Approximately 61,600 cubic yards of clean sand material will be used for backfill behind the breakwaters. The backfill will be planted with marsh vegetation to maintain stability. The stone breakwaters will consist of armor stone and bedding stones and geotextile material.

(2) *Source of Fill materials*
Approximately 61,600 cubic yards of sand will be used to construct the wetlands. Potential sources include dredging from off-shore borrow sites, using clean dredged material from nearby federal channels, or commercial sources barged to the island. In each case, the materials will be clean sand, free of contaminants. An additional 120,000 tons of armor stone and 60,200 tons of bedding stones would be used to construct the offshore breakwaters. The stone will be imported from commercial quarries.

e. Description of the Proposed Discharge Site

The discharge sites will be on the western shoreline of Martin Wildlife Refuge, from Swan Island to Fog Point Cove, the east and western shorelines of Fog Point Cove, and along the northwest and southeast shoreline of Back Cove. The proposed breakwater system would be located in shallow waters, approximately 30 feet to 100 feet channelward of the existing shoreline.

f. Description of fill materials and Placement Method

Breakwaters will be built approximately 30 feet to 100 feet off-shore, and material will be placed directly behind the structures, tying the structures into the existing marsh. The placed material will be graded and planted to blend into the existing marsh. This will require an estimated 61,600 cubic yards of sand fill material to develop 26 acres of marsh. If dredging is required, hydraulic dredging techniques will be used to pump material behind the breakwaters. The material will be placed after the construction of the breakwaters and will stabilize the structure and tie it into the existing marsh. If dredging is required, the dredging will be conducted in coordination with the resource agencies to reduce adverse environmental impacts. Best-management practices will be used, including time of year restrictions, the design of the dredging footprint, and the location and source of the dredged material. If the material is barged, the fill will be pumped behind the breakwaters from the directly from the barge.

g. Alterations Considered

Fill will be placed to avoid sensitive areas of the bay bottom, including oyster bars, SAV beds, or known spawning areas. If dredging is required, the footprint will be designed to avoid sensitive areas and minimize impact from material removal. If required, the dredging footprint will be designed in close coordination with the resource agencies. Alterations can include changes to dredging depth, shape, or site location.

II. Factual Determinations

a. Physical and Substrate Determinations

(1) *Substrate elevation and slope* – Elevation of Smith Island is very gentle, with an average elevation of 1ft. above mean high water. Water depths off the western and southern shorelines are very shallow, with an average range of 1-2ft. The breakwaters are designed to follow the 1.5 ft. contour on the Bay floor.

(2) *Sediment Type* – Sediment on Smith Island is predominately silt. Off shore borings have shown similar characteristics for the bottom sediment, although sandy areas have been discovered. An area off the western shoreline has been found to contain fine sand and may be used as a borrow material source.

(3) *Dredged/Fill Material Movement* – An equilibrium is expected to develop behind the breakwaters, creating the crescent shaped peninsulas commonly observed behind breakwaters. The material is expected to stabilize within a full season after construction. Wave and tidal action, the predominate causes of erosion, are expected to be reduced by the proposed project and no significant material movement is expected.

(4) *Other Effects* – Wave energy is expected to be reduced, reducing erosion on the island.

(5) *Actions Taken to Minimize Impacts* – Turbidity curtains may be used during construction to minimize impacts. If dredging is required, the dredging footprint will be developed to minimize adverse impacts to the Bay. In addition, if dredging is required, time of year restrictions and other best management practices will be used to minimize adverse impacts. Borrow locations will avoid all known SAV beds, oyster bars, and other sensitive areas. Construction specifications will require mandatory compliance with requirements for pollution control and abatement.

b. Water Circulation, Fluctuation, and Salinity Determinations

(1) *Water*

(a) Salinity - No change expected.
(b) Chemistry - No change expected.
(c) Clarity - Minor and temporary reduction expected during construction due to turbidity. No long-term impact expected.
(d) Color - Minor and temporary change expected during construction due to minor increase in turbidity. No long-term impact expected.
(e) Odor - No change expected.
(f) Taste - Not applicable.
(g) Dissolved Gas Levels - No change expected.
(h) Nutrients - No change expected.
(i) Eutrophication - Not expected to occur.
(j) Temperature - No change expected.

(2) *Current Patterns and Circulation*

(a) Current Patterns and Flow - No change expected.
(b) Velocity - No change expected.
(c) Stratification - No change expected.
(d) Hydrologic Regime - No change expected.

(3) *Normal Water Level Fluctuations* - No change expected.
(4) *Salinity Gradients* - No change expected.
(5) *Actions That Will Be Taken to Minimize Impacts* – Seasonal restrictions will be placed on construction activity to avoid the growing season, minimizing the impact on nearby SAV. Turbidity curtains may be used to reduce discharge during construction. Best management practices will be used to reduce impact.

c. Suspended Particulate/Turbidity Determinations

(1) *Expected Changes in Suspended Particulates and Turbidity Levels in Vicinity of Placement Site* - Minor, localized, and short-term impacts are expected to occur during both dredging and placement. Coarse grain-size material will rapidly settle out of suspension. Turbidity levels are expected to rapidly return to background levels once dredging is completed.

(2) *Effects (degree and duration) on Chemical and Physical Properties of the Water Column*
(a) Light Penetration - Minor, temporary, and localized reduction in light penetration due to turbidity may occur during dredging and placement sites between the breakwaters.
(b) Dissolved Oxygen - Minor, temporary, and localized reduction in dissolved oxygen due to turbidity may occur during construction.
(c) Toxic Metals and Organics - No toxic metals or organics are expected to be released into the water column.
(d) Pathogens - No pathogens are expected to be released into the water column.
(e) Aesthetics - No change expected.
(f) Temperature - No change expected.

(3) *Actions Taken to Minimize Impacts* – Turbidity curtains may used to minimize impacts of turbidity during construction. Environmental windows will be used to prevent turbidity impacts on nearby SAV. All work will conform to the requirements of the state water quality certificate. Construction specifications provided to the contractor state that compliance is mandatory for all applicable environmental protection regulations for pollution control and abatement.

d. Contaminant Determinations
Environmental coordination letters and historical research indicate that no contaminant sources are located in the area which will be affected by the construction. Clean fill materials will be used so that no significant levels of contaminants are anticipated to be released into the water column.

e. Aquatic Ecosystem and Organism Determinations

(1) *Effects on Plankton* - Impacts from the discharge of fill materials which will result in increased turbidity during construction are anticipated to be minor and temporary. No detrimental long-term impacts are expected.

(2) *Effects on Benthos* – The discharge of the fill materials will destroy relatively non-motile benthic organisms that inhabit the site. Approximately 26 acres of shallow water habitat will be converted to wetlands. Shallow water habitat is plentiful in the area and the loss is not expected to be significant. It is expected that benthos will recolonize the new habitat created by the placement of the large size rocks of the breakwaters. Negligible and temporary impacts to benthos in areas adjacent to the placement sites may occur during construction as a result of increased turbidity.

(a) Primary Production, Photosynthesis - Minor, temporary, and localized reduction in photosynthesis and primary production due to turbidity may occur during construction.

(b) Suspension/Filter Feeders – The discharge of fill materials and breakwaters will destroy relatively non-motile suspension/filter feeders that inhabit the borrow site. Minor, temporary, and localized impacts to suspension and filter feeders in the borrow and placement areas may occur due to turbidity created by construction activities. Suspension and filter feeders are expected to recolonize the beach stabilization sites and recover to pre-project levels within several months to a year following project construction.

(c) Sight Feeders - Minor, temporary, and localized impacts due to turbidity may occur during construction. Nonsignificant change expected after construction.

(3) *Effects on Nekton* - The discharge of fill materials and temporary construction activities is anticipated to temporarily affect the distribution of nektonic organisms, which may relocate away from the project area.

(4) *Effects on Aquatic Food Web* - The aquatic food web is anticipated to be temporarily impacted to a minor degree by loss of benthos at the beach stabilization project sites.

(5) *Effects on Special Aquatic Sites*

(a) Sanctuaries and Refuges - This project will have a large beneficial impact on Martin National Wildlife Refuge, through erosion protection, SAV restoration, and marsh protection.

(b) Wetlands - The project will create 26 acres of wetlands and connect the existing marsh to the created wetlands. This is expected to provide protection and add habitat for fish and wildlife.

(c) Tidal flats - The project will not directly impact any tidal flats, as few tidal flats are found within the high energy areas. Some tidal flats may be created between the breakwater system, creating habitat and a food source for the many avian species of the refuge.

(d) Vegetated Shallows - SAV has been found off the western shoreline. Construction designs have been carefully selected to avoid vegetated areas. By reducing erosion, there may be an increase in light attenuation, leading to beneficial effects on local SAV beds.

(6) *Threatened and Endangered Species* - Coordination with the Fish and Wildlife Service has indicated that no federal threatened or endangered species are known to inhabit the project except in isolated cases. Transient species have been found, but no known resident populations are known to exist. If threatened or endangered species are found, the appropriate resource agencies will be notified and the proper actions taken. See Appendix A, FWS planning aid report for more details. Thus, no adverse effects on threatened or endangered species are expected.

(7) *Other Wildlife* - It is expected that shorebirds, terrapins, and other mobile species will temporarily relocate during construction.

(8) *Actions to Minimize Impact* - The existence of high-value SAV is of primary concern within the project area. Designs that avoid the SAV beds have been selected to minimize impact. Winter construction schedules will be used to minimize effects on SAV during the growing season. Use of turbidity curtains may also be used to further minimize impacts.

<u>f. Proposed Disposal Site Determinations</u>

(1) *Mixing Zone Determination* - Not applicable.
(2) *Determination of Compliance with Applicable Water Quality Standards* - Construction activities will be conducted in accordance with all applicable state water quality standards.
(3) *Potential Effects on Human Use Characteristic*

(a) Municipal and Private Water Supply - Not applicable.

(b) Recreational and Commercial Fisheries - Construction may temporarily impede navigation activity. A winter construction schedule will be used to minimize impacts to the local fishing economy.

(c) Water Related Recreation - Construction may temporarily impede recreational boat use. The impacts are expected to be minor and temporary. A winter construction schedule will reduce impacts on most recreational boating.

(e) Aesthetics - A temporary and minor reduction in aesthetic value within the area of construction is expected to occur during placement of the breakwaters and fill materials. Long-term improvements are expected through the increase in marsh and SAV.

(f) Parks, National and Historical Monuments, National Seashores, Wilderness Areas, Research Sites, and Similar Preserves – No adverse effects are expected.

h. <u>Determination of Cumulative Effects on the Aquatic Ecosystem</u> – This project will effectively reduce erosion throughout the western and northern section of Smith Island, and the restore and protect of over 1500 acres of marsh and SAV habitat. Minor losses of shallow water habitat will be off-set by long-run protection of existing SAV, wetlands and uplands. Reduced erosion will reduce the sediment discharge within the project area, providing a positive benefit to local SAV beds by increasing light attenuation. Thus, cumulative adverse effects on the aquatic ecosystem are expected to be minor and large beneficial impacts are expected in the local area.

h. Determinations of Secondary Effects on the Aquatic Ecosystem - Indirect effects resulting from the project have been discussed previously in this analysis under each category. No significant detrimental secondary effects are anticipated.

III. Finding of Compliance

a. Adaptation of the Section 404(b)(1) Guidelines to This Evaluation - No adaptations of the Guidelines were made relative to this Evaluation.

b. Evaluation of Availability of Practicable Alternatives to the Proposed Discharge Site Which Would Have Less Adverse Impact on the Aquatic Ecosystem. - The project is by its nature water-dependent and will require activity within the aquatic realm.

c. Compliance With Applicable State Water Quality Standards. - The proposed placement of fill material will be in compliance with Maryland state water quality standards.

d. Compliance With Applicable Toxic Effluent Standard or Prohibition Under Section 307 of the Clean Water Act. - The proposed fill material is not anticipated to violate the Toxic Effluent Standard of Section 307 of the Clean Water Act.

e. Compliance With Endangered Species Act of 1973 – The project is in full compliance with the endangered species act.

f. Compliance With Specified Protection Measures for Marine Sanctuaries Designated by the Marine Protection, Research, and Sanctuaries Act of 1972 - No Marine Sanctuaries, as designated in the Marine Protection, Research, and Sanctuaries Act of 1972, are located within the study area. The project is located off-shore of Martin Wildlife Refuge and the project is expected to have beneficial impacts on the refuge by reducing erosion.

g. Evaluation of Extent of Degradation of Waters of the United States - The proposed placement of fill material will not result in significant adverse impacts on human health and welfare, including municipal and private water supplies, recreation and commercial fishing, plankton, fish and shellfish, wildlife, and special aquatic sites. The life stages of aquatic life and wildlife will not be significantly adversely affected. Significant adverse impacts on aquatic ecosystem diversity, productivity and stability, and recreation, aesthetics and economic values will not occur as a result of the project.

i. Appropriate and Practicable Steps Taken to Minimize Potential Adverse Impacts of the Discharge on the Aquatic Ecosystem – if dredging is required, the dredging footprint will be designed to minimize environmental impact, in consultation with the resource agencies. The footprints will avoid sensitive areas and use all best-management practices to ensure resource protection. In addition, turbidity curtains will be used. Time of year restrictions will be placed on dredging and fill activities, and construction specifications will require compliance with all regulatory actions. In addition, the project will be designed to avoid sensitive off-shore areas, such as SAV or oyster bars.

ANNEX A
Evaluation for Planned Wetland Information
Functional Assessment

Contents:

Summary Sheet on Evaluation for Planned Wetlands (EPW) Method
Main Author: Dr. Candy Bartoldus, Environmental Concern, Inc., 1994

EPW is a **rapid assesment method** which takes aspects of FWS' HEP methodology (habitat suitability x acres = unit score) and incorporates a number of the wetland functions that the Hydrogeomorphic Approach to Assessment of Wetland Functions (HGM) strives to quantify.

EPW compares an existing wetland site slated for action (the Wetland Assessment Area) to a Planned Wetland to plan for or determine any change in wetland functions from a project. The EPW method can also be used to assess a reference wetland not in the project area, with which to compare the planned wetland.

Benefits/Applicability of EPW to Smith Island restoration and protection

1) locally developed, well suited for tidal wetland creation/restoration projects
2) has credibility and is fairly well known in Mid Atlantic coastal region
3) Rapid assessment, suitable for planning level analysis
4) transparent as to the calculation of scores - easily understandable and explainable
5) Quantifies more than just habitat function
6) Generally conducted by multi-agency team in the field, to agree on interpretation and discuss scoring
7) Scoring and model assumptions able to be modified by consensus of the assessment team, then documented

Wetland functions in EPW that may be assessed (if applicable):

1) Shoreline Bank Erosion Control
2) Sediment Stabilization
3) Water Quality
4) Wildlife
5) Fish
6) Uniqueness/Heritage

Limitations of EPW application:

1) Method only looks at the project area, it is not a landscape level assessement
2) As a rapid analysis, has a lower level of accuracy than more detailed analysis
3) Describes only wetland areas, not uplands or buffers.
4) Does not replace professional judgement
5) Makes assumptions about the relationship between wetland size and function that may not be accurate.

Janet Norman, FWS

Summary of Smith Island Findings:

The marsh on Smith Island was evaluated on six different wetland functions. While these scores are relative The scores and functions are shown below and the data sheets are attached to this document:

- Shoreline Bank Erosion Control: 0.44
- Sediment Stabilization: 0.55
- Water Quality: 0.70
- Tidal Fish: 0.46
- Wildlife Habitat: 0.64
- Uniqueness/Heritage: 1.00

Analysis: The functional assessment scores show that the Smith Island marsh has high values for sediment stabilization, water quality, and wildlife habitat, and very high scores for uniqueness and heritage. This indicates that the marsh has an excellent diversity of habitat areas and species, provides a large benefit to the local water quality, and anchors the island sediment. These findings are in-keeping with the overall analysis of the smith island system, which indicates that it is a unique and valuable system within the Bay watershed, providing a rare expanse of island wetlands, punctuated by isolated uplands. For this reason, Smith Island had the highest uniqueness/heritage score. However, the marsh scores slightly lower for shoreline bank erosion control and tidal fish habitat. This is not surprising, as the marsh remains impacted by severe erosion, creating steep slopes between the marsh and the open water, limiting access by tidal fish.

Conclusions: The proposed project, by preventing further erosion, would reduce the necessity of the shoreline bank erosion control function and help increase tidal fish access to the pristine interior of the marsh. The marsh system will continue to degrade without stabilization. Thus, the proposed project would increase the functional scores of the marsh.

Wetland Assessment for Smith Island

Site visit conducted 11/17/99 FWS: J. Norman, J. Gill Corps: S. Kopecki, D. Bierly

Shoreline Bank Erosion Control Function

Element	Number	Not Applic?	W.A.A. 1
Bank Characteristics	1a		0.1
Fetch	2		0.1
Slope	14		0.1
Structures	3	NA	1.0
Fetch	2		0.1
Disturbance	4a	NA	1.0
Surface runoff	5a	NA	1.0
Boat waves	6	NA	1.0
Hydroperiod	7a	NA	1.0
Sunlight	8	NA	1.0
Substrate	9a	NA	1.0
Planned Slope	14b	NA	1.0
Upper shore cover	10a		1.0
Lower shore cover	10e		0.1
Upper plant height	10g		1.0
Root structure	10i		1.0
Veg. Persistence	10k		1.0
SBEC SCORE			0.44

Sediment Stabilization Function

Disturbance	4a	NA	1.0
Hydroperiod	7a	NA	1.0
%cover, wetland	10b		1.0
% cover, debris	10c		1.0
Root structure	10j		1.0
Veg. Persistence	10l		1.0
Wetland slope	14c		0.1
SS SCORE			0.55

Water Quality Function			
Hydrologic condit.	15		0.7
Disturbance	4b	NA	1.0
Hydroperiod	7a	NA	1.0
Size	16a	NA	1.0
Bank Characteristics	1a		0.1
Surface runoff	5b	NA	1.0
Wetland Slope	14c		0.1
% cover, wetland	10b		1.0
Plant height, wetland	10h		1.0
Veg. Persistence	10l		1.0
Substrate	9b		1.0
Hydrologic condit.	15		0.7
Detention time	17	NA	
Sheet/Channel Flow	18	NA	
Water Depth	19	NA	
WQ SCORE			**0.70**
Tidal Fish Habitat Function			
Passage barriers	24	NA	1.0
Bank Stability	1b		0.1
Disturbance	4a	NA	1.0
Channel Disturbance	4d	NA	1.0
Hydroperiod	7b	NA	1.0
Passage barriers	24	NA	1.0
Spatial Hydroperiod	7c		0.5
Substrate Suitability	9c		1.0
% Cover, Upper Shore	10d		1.0
% Cover, SAV	10f		0.1
Shape of Edge	21b		1.0
Fish Cover/Attractors	22b		0.1
Water Quality	20b		1.0
Contaminant Sources	20c		1.0
Dissolved Oxygen	20d		1.0
Max Summer Temp	20f		1.0
Fish SCORE			**0.46**

Wildlife Habitat Function							
Disturbance	4c	NA	1.0				
Size	16b	NA	1.0				
Contamination	20a	NA	1.0				
# Layers in Wetland	11a		0.7				
Condition of Layers	11b		0.3				
Pattern of Tree/Shrub	11c		1.0				
Difference WAA/PW	11d	NA	1.0				
# of Cover Types	12a		0.22				
Ratio of Cover Types	12b		0.1				
Degree Interspersion	12c		0.1				
Undesirable Species	12d	NA	1.0				
Difference WAA/PW	12e	NA	1.0				
% Open Water	13a		0.5				
Veg/water Interspersion	13b		1.0				
Shape of Edge	21a		1.0				
Wildlife Attractors	22a	NA	1.0				
Islands	23		1.0				
Wildlife SCORE			0.64				
Uniqueness/Heritage Function							
Endangered Species	29		1.0				
Rare/uncommon site	30		1.0				
Rare features	31		1.0				
Historic component	32		1.0				
Natural Landmark	33		1.0				
Wild + Scenic River	34	NA					
Refuge Ownership	35		1.0				
Science Research	36		1.0				
Heritage SCORE			1.0				

EVALUATION FOR PLANNED WETLANDS (EPW)
Cover Sheet

PROJECT TITLE:

ASSESSMENT DATE(S): *WAA:* *planned wetland:*

INDIVIDUAL(S) PERFORMING EVALUATION AND AFFILIATION:

LOCATION (e.g., City, County, State, Waterway/Watershed):

WAA:

planned wetland:

ASSESSMENT OBJECTIVES:
(note assumed point in time, e.g., peak of first growing season for planned wetland)

CHECK FUNCTIONS ASSESSED:	*WAA*	*planned wetland*
Shoreline Bank Erosion Control		
Sediment Stabilization		
Water Quality		
Wildlife		
Fish (Tidal)		
Fish (Non-tidal Stream/River)		
Fish (Non-tidal Pond/Lake)		
Uniqueness/Heritage		

DESCRIPTION OF PROJECT AREA:
Include information relevant to the assessment (e.g., NWI classification, description of hydrogeomorphic class(es), land use, climate).

WAA:

planned wetland:

...cover sheet continues on reverse

Table A.1.
Comparison of WAA and planned wetland: calculations of FCIs and FCUs

Project Title:

Comparison between WAA # ___________ and planned wetland # ___________

Function	WAA			Goals for Planned Wetland**					Planned Wetland			Check if goals met
	FCI	AREA	FCUs*	Target FCI	R	Target FCUs	Predicted FCI	Minimum Area	FCI	AREA	FCUs*	
SB												
SS												
WQ												
WL												
FT												
FS												
FP												
UH												

*FCUs = FCI x AREA
**Target FCI = *goal* established by decision makers
R = multiplying factor established by decision makers
Target FCUs = $FCU_{WAA} \times R$ (i.e., planned wetland *goal*)
Predicted FCI = FCIs which designers presume planned wetland may achieve at a particular site (Note this may be greater than Target FCI).
Minimum Area = Target FCUs/Predicted FCI

Table A.2.
Comparison of FCIs and element scores

PROJECT TITLE:

Function	Functional Capacity Index		Elements with different scores for WAA and planned wetland		
	WAA	Planned Wetland	Element Number	Difference	Explanation
Shoreline Bank Erosion Control (SB)		Target!			
Sediment Stabilization (SS)		Target!			

Table A.2.
Comparison of FCIs and element scores

PROJECT TITLE:

Function	Functional Capacity Index		Elements with different scores for WAA and planned wetland		
	WAA	Planned Wetland	Element Number	Difference	Explanation
Water Quality (WQ)		Target:			
Wildlife (WL) *Reminder: Include elements 11d and/or 12e if there are differences in scores		Target:			

Table A.2. (page 2 of 3)

Table A.2.
Comparison of FCIs and element scores

PROJECT TITLE:

Function	Functional Capacity Index		Elements with different scores for WAA and planned wetland		
	WAA	Planned Wetland	Element Number	Difference	Explanation
Fish (FT, FS, FP)		Target:			
Uniqueness/Heritage (UH)		Target:			

Table A.2. (page 3 of 3)

PROJECT TITLE: ____________________

SHORELINE BANK EROSION CONTROL
DATA SHEETS

Function weighting area (AREA) = The shore, i.e., the vegetated or non-vegetated areas of the wetland located channelward of the bank (see Figure A.2).

ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	For use in FCI Model: SELECTED SCORES FOR ELEMENTS — WAA	Planned Wetland	For use in Table A.2 only: DIFFERENCE IN SCORES (Planned - WAA) If both scores are NA, record NA
Potential for erosion:				
1. Bank characteristics				Assume NA = 1.0
1a. Water contact with toe of bank **(see Figure A.1)**	[SB, WQ]*			
a. No shoreline bank.	NA			
b. Infrequent water contact at toe of bank, i.e., no undercutting of bank (e.g., contact once annually or less).	1.0			
c. Occasional water contact at toe of bank (e.g., contact once a month).	0.7			
d. Moderate water contact at toe of bank (moderate undercutting of bank).	0.5			
e. Frequent water contact at toe of bank (severe undercutting of bank).	0.1			

NOTE: If the score for element 1 = NA (no shoreline bank), there is no potential for providing the shoreline bank erosion control function; therefore the Shoreline Bank Erosion Control FCI is not applicable (NA). Continue only if score ≠ NA.

ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	WAA	Planned Wetland	DIFFERENCE IN SCORES
Site suitability for planned wetland (elements 2 and 14a):				
2. Fetch (Fetch = maximum distance over which wind can blow, unimpeded, across open water to generate waves)	[SB]			Assume NA = 1.0
a. < 1.6 km (1 mile).	1.0			
b. > 1.6 km (1 mile).	0.1			

* Denotes function(s) to which element applies: SB = Shoreline Bank Erosion Control; SS = Sediment Stabilization; WQ = Water Quality; WL = Wildlife; FT = Fish (Tidal); FS = Fish (Stream/River); FP = Fish (Pond/Lake); and UH = Uniqueness/Heritage

ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	SELECTED SCORES FOR ELEMENTS		DIFFERENCE IN SCORES (Planned - WAA) If both scores are NA, record NA
		WAA	Planned Wetland	
14. Slope				
14a. Steepness of existing shore [SB] (Shore = vegetated or non-vegetated substrate located channelward of the bank; See Figure A.2)				Assume NA = 1.0
a. Shore gradual (e.g., slope < 10:1).	1.0			
b. Shore steep (e.g., slope > 10:1).	0.1	NA		
If condition b, then record slope: ________				

NOTE: For planned wetland only. If score for elements 2 and/or 14a is 0.1, then the site is UNSUITABLE. The Shoreline Bank Erosion Control FCI will be low. Continue with data sheet for the planned wetland, only if scores for both elements ≠ 0.1.

ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	WAA	Planned Wetland	DIFFERENCE IN SCORES
Shoreline structures/obstacles:				
3. Shoreline structures/obstacles [SB]				Assume NA = 1.0
a. No shoreline structures present.	NA			
b. Structure/obstacle present. Shore erosion minimal	NA			
c. Structure/obstacle present. Moderate shore erosion problem present.	0.5			
d. Structure/obstacle present. Substantial shore erosion problem present.	0.1			

If structure/obstacle present, check type(s):

Structure/Obstacle	WAA	Planned Wetland
Bulkhead	____	____
Rubble	____	____
Riprap	____	____
Revetments (e.g., stone, concrete, gabion)	____	____
Breakwater	____	____
Groins	____	____
Beach fill	____	____
Bridge pier	____	____
Boat dock	____	____
Fallen trees	____	____
Debris	____	____
Potential for moving ice chunks	____	____
Other: ____________	____	____

ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	SELECTED SCORES FOR ELEMENTS		DIFFERENCE IN SCORES (Planned - WAA) If both scores are NA, record NA
		WAA	Planned Wetland	
Physical influences on rate of erosion (elements 2, 4a, 5a, 6, 7a, 8a, 9a, and 14b):				
2. Fetch (element already scored above)				
4. Disturbance				
4a. Disturbance at site (Sediment Stabilization)	[SB, SS, FT, FS, FP]			Assume NA = 1.0
(Do not include observations of debris)				
a. No or minimal disturbance.	NA			
b. Potential for periodic disturbance present, but preventative action taken (e.g., installation of enclosure fences for herbivores and/or human disturbance) -OR- if recently disturbed, soils sufficiently stabilized with mulch, seeding, or planting.	NA			
c. Moderate disturbance (e.g., disturbance of sediments only in portion of site; infrequent grazing by waterfowl).	0.5			
d. Evidence of substantial periodic disturbance which makes substrate unstable (e.g., muskrat eatouts, overgrazing by waterfowl, cattle grazing and trampling, nutria activity, human activity such as the use of off-road vehicles; wetland tilled, filled, logged, clear-cut or excavated and not stabilized by seeding or planting).	0.1			
5. Surface runoff from upslope areas (upland and/or wetland immediately adjacent to site).				
5a. Surface runoff from upslope areas (bank erosion)	[SB]			Assume NA = 1.0
a. Surface runoff from upslope areas not an apparent contributor to bank erosion at site (e.g., No or minimal evidence of surface erosion in upland areas, e.g., unstabilized gullies absent).	NA			
b. Surface runoff contribution to bank erosion minimal due to presence of effective infiltration and drainage controls in adjacent upslope areas (e.g., surface runoff through wetland conveyed by stabilized gullies; upslope surface cracks filled).	NA			
c. Surface runoff from upslope areas causes moderate bank erosion.	0.5			
d. Surface runoff from upslope areas causes substantial bank erosion.	0.1			

ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	SELECTED SCORES FOR ELEMENTS: WAA	SELECTED SCORES FOR ELEMENTS: Planned Wetland	DIFFERENCE IN SCORES (Planned - WAA) If both scores are NA, record NA
14. Slope				
14b. Steepness of planned wetland shore **(See Figure A.2)**	[SB]			Assume NA = 1.0
a. Shore gradual (e.g., slope < 5:1).	NA			
b. Shore steep (e.g., slope > 5:1).	0.1	NA		
If condition b, then record slope: ________				
Vegetation influences on the rate of erosion (elements 10a, 10e, 10g, 10i, and 10k):				
10. Vegetation characteristics during growing season (Note differences in definitions for upper shore zone, lower shore zone, and entire wetland. **See Figure A.2**).				
10a. Percent plant (basal) cover in **upper shore zone**. (Consider only those parts of vegetation which have contact with water flow. **See Figure A.3**)	[SB]			
a. Cover > 75%.	1.0			
b. Cover 51 - 75%.	0.7			
c. Cover 25 - 50%.	0.3			
d. Cover < 25%.	0.1			
10e. **Percent cover of rooted vascular aquatic beds in lower shore zone** which is subject to bottom erosion.	[SB]			Assume NA = 1.0
a. No lower shore zone (e.g., no open water).	NA			
b. Lower shore zone not subject to bottom erosion (e.g., no evidence of scouring, i.e., no wave ripples).	NA			
c. Cover > 75%.	1.0			
d. Cover 51 - 75%.	0.7			
e. Cover 25 - 50%.	0.5			
f. Cover < 25%.	0.1			
10g. Plant height in **upper shore zone**.	[SB]			
a. Average plant height equal to or taller than average high water level.	1.0			
b. Intermediate condition, i.e., approximately equal proportions of plants equal to or taller -AND- plants shorter than average high water level.	0.8			
c. Average plant height shorter than average high water level.	0.5			
d. Vegetation absent.	0.1			

ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	SELECTED SCORES FOR ELEMENTS		DIFFERENCE IN SCORES (Planned - WAA) If both scores are NA, record NA
		WAA	Planned Wetland	
10i. Root structure in upper shore zone.	[SB]			
Wetland predominantly vegetated by:				
a. Herbaceous species that form a root mat (e.g., rhizome propagating species).	1.0			
b. Intermediate condition.	0.8			
c. Herbaceous species that do not form a root mat (bulb [*Peltandra virginica*], tuber [*Sagittaria latifolia*], or bunch [*Carex spp.*] species).	0.5			
d. Woody species.	0.5			
e. Vegetation absent. Belowground root system absent or dead.	0.1			
10k. Vegetation persistence in upper shore zone.	[SB]			
Dominant plant cover:				
a. Persistent vegetation.	1.0			
b. Approximately equal proportions of persistent and non-persistent vegetation.	0.8			
c. Non-persistent vegetation.	0.5			
d. Vegetation absent.	0.1			

Calculation of **SHORELINE BANK EROSION CONTROL** FCI

PROJECT TITLE: ____________

Selected Scores	(#)	Element

COMPARISON: ____________ (e.g., WAA/planned wetland)

Site Suitability For Planned Wetland:

MILE.

______	(2)	Fetch
______	(14a)	Steepness of existing shore

If result = 0.1 for either element, then the planned wetland site is UNSUITABLE
If result ≠ 0.1 for both elements, then continue with model

______	(1a)	Water contact with toe of bank

→ If result = NA, then STOP. **Shoreline Bank Erosion Control FCI** = NA
→ If other, record score → 1a = ______ Potential for Erosion (E)

______	(3)	Shoreline structures/obstacles

→ 3 = ______ Shoreline Structures/ Obstacles

______	(2)	Fetch
______	(4a)	Disturbance at site (SS)
______	(5a)	Surface runoff (bank erosion)
______	(6)	Boat traffic
______	(7a)	Water level fluctuation
______	(8a)	Hours of sunlight
______	(9a)	Substrate suitability for vegetation
______	(14b)	Steepness of planned wetland shore

JBS
W/EMERGENT

average for elements with available scores = ______ Physical Influences on Rate of Erosion

______	(10a)	Plant (basal) cover
______	(10e)	Rooted vascular aquatic beds
______	(10g)	Plant height
______	(10i)	Root structure
______	(10k)	Vegetation persistence

Equation #5 or #6 = ______ Vegetation Influences on Rate of Erosion

average for available scores = ______ Influences on Rate of Erosion (I)

$\frac{E + I}{2}$ = ______ **Shoreline Bank Erosion Control FCI**

Equation #5:

If 10e applicable:

$$\frac{10a\ (10g + 10i + 10k) + 10e}{4}$$

Equation #6:

If 10e not applicable:

$$\frac{10a\ (10g + 10i + 10k)}{3}$$

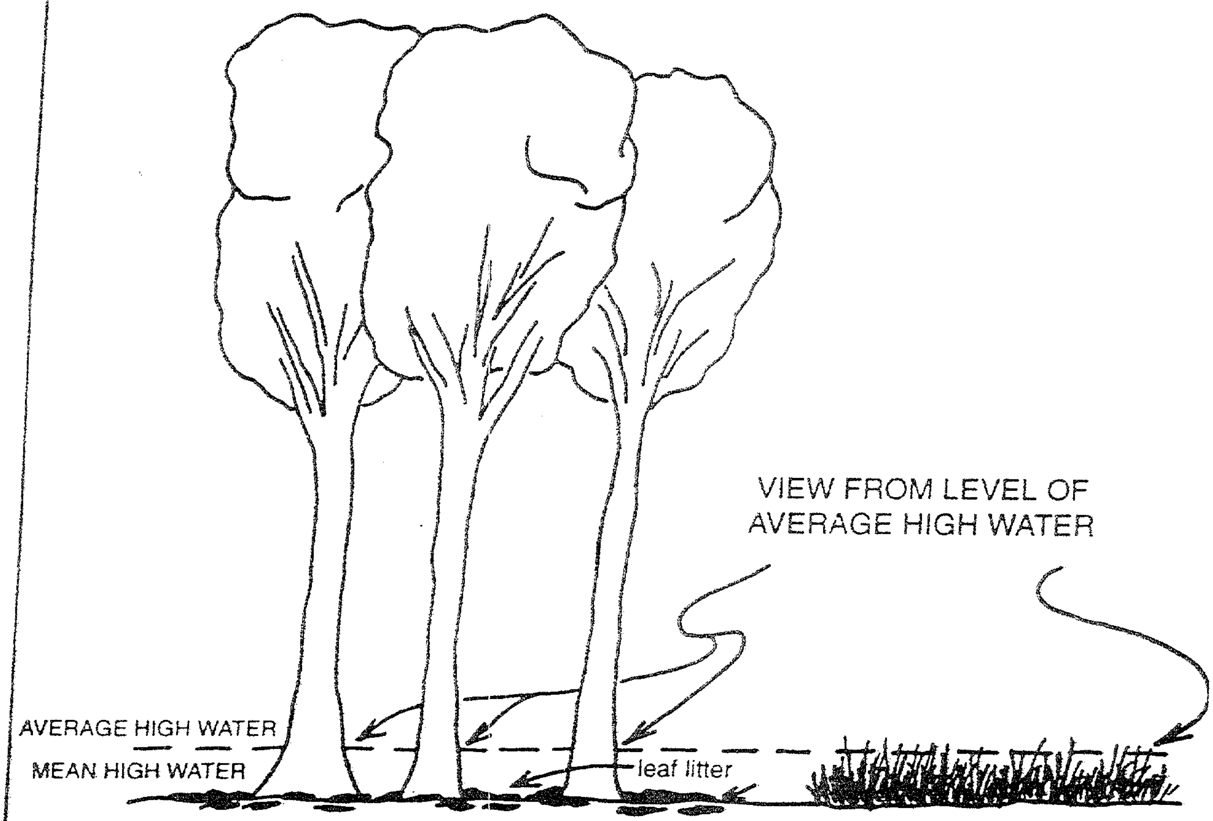
PROJECT TITLE: ______________________________

SEDIMENT STABILIZATION DATA SHEETS

Function weighting area (AREA) = Entire wetland assessment area

		For use in FCI Model		For use in Table A.2 only
ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	SELECTED SCORES FOR ELEMENTS		DIFFERENCE IN SCORES (Planned - WAA) If both scores are NA, record NA
		WAA	Planned Wetland	
Disturbance factors (elements 4a and 7a):				
4a. Disturbance (Sediment Stabilization)	[SB, SS, FT, FS, FP]*			Assume NA = 1.0
(Do not include observations of debris)				
a. No or minimal disturbance.	NA			
b. Potential for periodic disturbance present, but preventative action taken (e.g., installation of exclosure fences for herbivores and/or human disturbance). OR If recently disturbed, soils sufficiently stabilized with mulch, seeding, or planting.	NA			
c. Moderate disturbance (e.g., disturbance of sediments only in portion of site; infrequent grazing by waterfowl).	0.5			
d. Evidence of substantial periodic disturbance which makes substrate unstable (e.g., muskrat eatouts, overgrazing by waterfowl, cattle grazing and trampling, nutria activity, human activity such as the use of off-road vehicles; wetland tilled, filled, logged, clear-cut or excavated and not stabilized by seeding or planting).	0.1			

* Denotes function(s) to which element applies: SB = Shoreline Bank Erosion Control; SS = Sediment Stabilization; WQ = Water Quality; WL = Wildlife; FT = Fish (Tidal); FS = Fish (Stream/River); FP = Fish (Pond/Lake); and UH = Uniqueness/Heritage



Examples:

	Forest	Emergent Marsh
Percent (Basal) Cover (Elements 10a, 10b, or 10d)	<25%	>75%
Percent Leaf Litter & Debris Cover (Element 10c)	>75%	Ground surface areas almost entirely covered by live vegetation

Figure A.3.
Percent plant cover (elements 10a, 10b, 10c, and 10d)

Calculation of **SEDIMENT STABILIZATION** FCI

PROJECT TITLE: ____________________

COMPARISON: ________________________(e.g., WAA/planned wetland)

Selected Scores	(#)	Element
________	(4a)	Disturbance at site (SS)
________	(7a)	Water level fluctuation
________	(10b)	Plant (basal) cover
________	(10c)	Leaf litter and debris cover
________	(10j)	Root structure
________	(10l)	Vegetation persistence
________	(14c)	Wetland slope

(4a), (7a) → **If both 4a and 7a = NA**, record NA. If not, then record lowest score from 4a or 7a → = ________ Disturbance Factors (DF)

(10b), (10c), (10j), (10l) → Equation #7 = ________ Vegetation Characteristics (V)

(14c) → 14 = ________ Slope Stability (S)

$\frac{V + S}{2}$ = ________ Wetland Characteristics (W)

If DF ≠ NA: $\frac{DF + W}{2}$ = ________ **Sediment Stabilization FCI**

If DF = NA: W → ________ **Sediment Stabilization FCI**

Equation #7:

$$\frac{10b\,(10j + 10l) + 10c\,(1 - 10b)}{2}$$

PROJECT TITLE: ______________________

WATER QUALITY
DATA SHEETS

Function weighting area (AREA) = Entire wetland assessment area

		For use in FCI Model		For use in Table A.2 only
ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	SELECTED SCORES FOR ELEMENTS		DIFFERENCE IN SCORES (Planned - WAA) If both scores are NA, record NA
		WAA	Planned Wetland	
Applicability of water quality function (element 15):				
15. Hydrologic condition (Define hydrologic condition of non-tidal wetland site by considering its position in the landscape) **(See Figure A.4 for non-tidal** wetland conditions)	(WQ)*			Assume NA = 0
a. Non-tidal, Condition A.	NA			
b. Non-tidal, Condition B.	NA			
c. Non-tidal, Condition C.	1.0			
d. Non-tidal, Condition D.	0.8			
e. Non-tidal, Condition E.	0.3			
f. Non-tidal, Condition F.	0.3			
g. Non-tidal, Condition G.	0.1			
h. Non-tidal, Condition H.	0.1			
i. Tidal, site predominantly low marsh.	1.0			
j. Tidal, site approximately equal proportions of high and low marsh.	0.7			
k. Tidal, site predominantly high marsh.	0.5			

If the score for element 15 = NA, then the Water Quality FCI is considered not applicable (NA) because there is no outlet to convey surface water from the wetland downstream. Continue only if information on elements is required for comparison between wetlands.

* Denotes function(s) to which element applies: SB = Shoreline Bank Erosion Control; SS = Sediment Stabiliation; WQ = Water Quality; WL = Wildlife; FT = Fish (Tidal); FS = Fish (Stream/River); FP = Fish (Pond/Lake); and UH = Uniqueness/Heritage

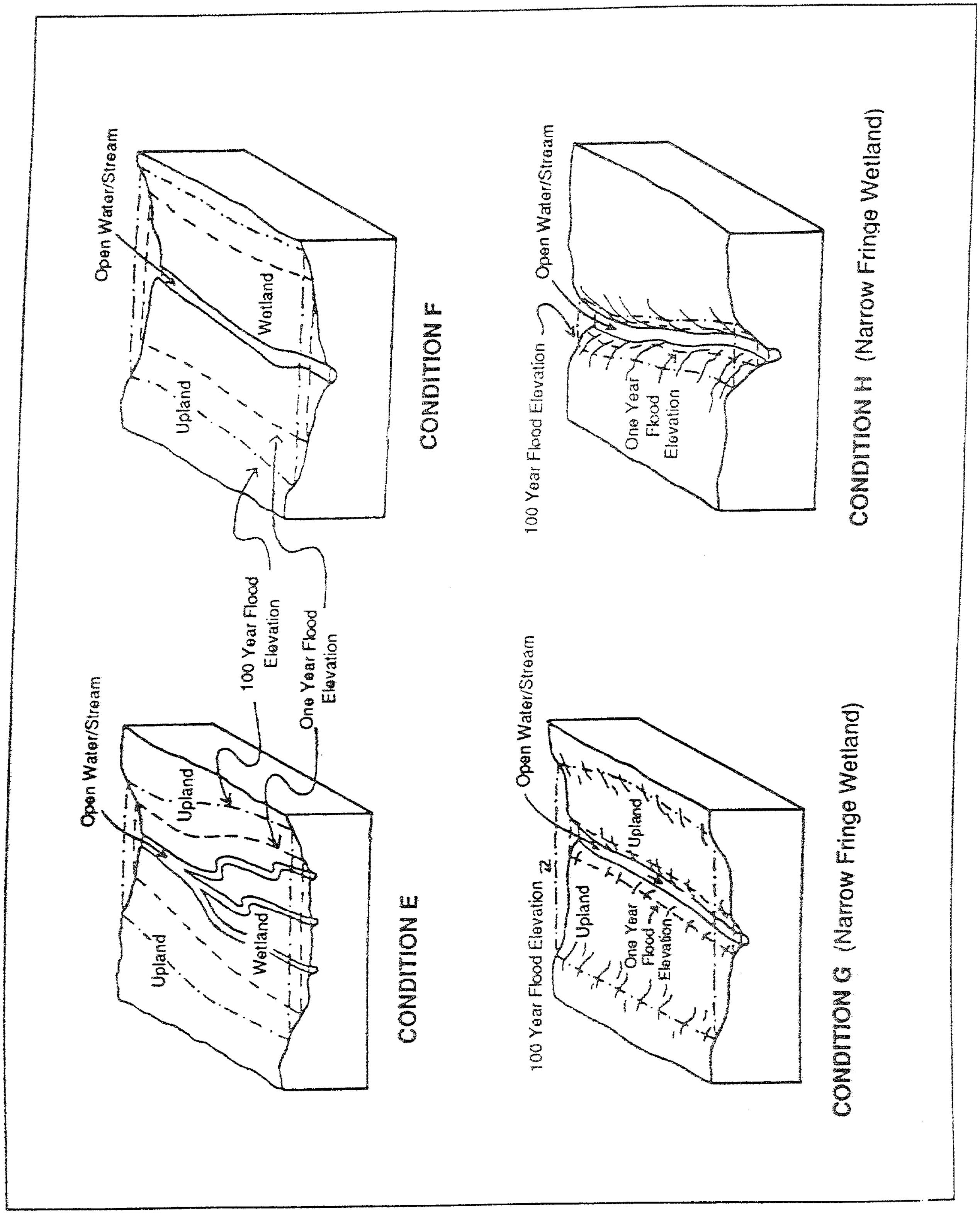


Figure A.4. *(con't from p. A 20)*
Non-tidal hydrologic condition (element 15; modified from Hollands and McGee 1986)

ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	SELECTED SCORES FOR ELEMENTS: WAA	SELECTED SCORES FOR ELEMENTS: Planned Wetland	DIFFERENCE IN SCORES (Planned - WAA) If both scores are NA, record NA
16. Size				
16a. *Wetland width*	[WQ]			Assume NA = 1.0
Is the site considered to have a low potential to improve water quality because of its narrow width (e.g., wetland < 2 feet wide)?				
a. No.	NA			
b. Yes.	0.1			
If yes explain: ______________________				
Substrate-slope characteristics affecting water quality (elements 1a, 5b, and 14c):				
1. Bank characteristics	[SB, WQ]			Assume NA = 1.0
1a. Water contact with toe of bank (see Figure A.1)				
a. No shoreline bank.	NA			
b. Infrequent water contact at toe of bank, i.e., no undercutting of bank (e.g., contact once annually or less).	1.0			
c. Occasional water contact at toe of bank (e.g., contact once a month).	0.7			
d. Moderate water contact at toe of bank (moderate undercutting of bank).	0.5			
e. Frequent water contact at toe of bank (severe undercutting of bank).	0.1			

ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	SELECTED SCORES FOR ELEMENTS: WAA	SELECTED SCORES FOR ELEMENTS: Planned Wetland	DIFFERENCE IN SCORES (Planned - WAA) If both scores are NA, record NA
5. Surface runoff from upslope areas				
5b. Surface runoff from upslope areas (erosion of bank and wetland proper)	[WQ]			Assume NA = 1.0
a. Surface runoff from upslope areas not an apparent contributor to erosion in the wetland (e.g., No or minimal evidence of surface erosion in upland areas, e.g., unstabilized gullies absent).	NA			
b. Surface runoff contribution to wetland erosion minimal due to presence of effective infiltration and drainage controls in adjacent upslope areas (e.g., surface runoff through wetland conveyed by stabilized gullies; upslope surface cracks filled).	NA			
c. Surface runoff from upslope areas causes moderate wetland erosion.	0.5			
d. Surface runoff from upslope areas causes substantial wetland erosion	0.1			
14. Slope				
14c. Vegetated or unvegetated wetland slope (Entire wetland)	[SS, WQ]			
a. Slope is stable with and/or without vegetation (e.g., a slope which is adjusted to the wave climate would be stable even in the absence of vegetation).	1.0			
b. Slope is stable. Erosion protection provided by leaf litter and debris	1.0			
c. Slope is unstable (e.g., an unvegetated slope with gullies; evidence of a net loss of shore sediments beginning the development of a bank; evidence of scouring, i.e., wave ripples.)	0.1			
Vegetation characteristics affecting water quality (elements 10b, 10h, and 10i):				
10. Vegetation characteristics during growing season				
10b. Percent plant (basal) cover, including rooted vascular aquatic beds, in entire wetland. (Consider only those parts of vegetation which have contact with water flow. See Figure A.3)	[SS, WQ]			
a. Cover > 75%.	1.0			
b. Cover 51 - 75%.	0.7			
c. Cover 25 - 50%.	0.3			
d. Cover < 25%.	0.1			

ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	SELECTED SCORES FOR ELEMENTS: WAA	SELECTED SCORES FOR ELEMENTS: Planned Wetland	DIFFERENCE IN SCORES (Planned - WAA) If both scores are NA, record NA
10h. Plant height in entire wetland. (Include rooted vascular aquatic beds)	[WQ]			Assume NA = 0
a. Average plant height equal to or taller than average high water level.	1.0			
b. Intermediate condition, i.e., approximately equal proportions of plants equal to or taller -AND- plants shorter than average high water level.	0.8			
c. Average plant height shorter than average high water level.	0.5			
d. Vegetation absent.	0.1			
10i. Vegetation persistence in entire wetland. (Include rooted vascular aquatic beds)	[SS, WQ]			
Dominant plant cover:				
a. Persistent vegetation.	1.0			
b. Approximately equal proportions of persistent and non-persistent vegetation.	0.8			
c. Non-persistent vegetation.	0.5			
d. Vegetation absent.	0.1			
Elements defining the extent of water contact with wetland surface (elements 9b, 15, 17, 18, and 19):				
9. Substrate				
9b. Dominant substrate type	[WQ]			
a. Fine mineral soils (e.g., alluvial, alfisol, loam, ferric, clay) -OR- soils with high organic content (> 20% by weight).	1.0			
b. Medium sized sand.	0.5			
c. Course sand, bedrock, rubble, or cobble.	0.1			
15. Hydrologic condition (element already answered above).				

Calculation of **WATER QUALITY** FCI

PROJECT TITLE: ____________

Selected Scores	(#)	Element

COMPARISON: ________________(e.g., WAA/planned wetland)

Selected Scores	(#)	Element	
______	(15)	Hydrologic condition	**If result = NA, then STOP. Water Quality FCI** is not applicable. **If score selected,** then continue with model.

Selected Scores	(#)	Element	
______	(4b)	Disturbance at site (WQ)	**If all results = NA, record NA** **If score(s) selected, then calculate average** for elements with available scores = ______ Limiting Factors (LF)
______	(7a)	Water level fluctuation	
______	(16a)	Wetland width	
______	(1a)	Water contact with toe of bank	average for elements with available scores = ______ Substrate-Slope Characteristics (SS)
______	(5b)	Surface runoff (wetland erosion)	
______	(14c)	Wetland slope	
______	(10b)	Plant (basal) cover	Equation #8 = ______ Vegetation Characteristics (V)
______	(10h)	Plant height	
______	(10l)	Vegetation persistence	
______	(9b)	Dominant substrate	**If scores different, include in average for WC** **If scores same, do not include in average.**
______	(15)	Hydrologic condition	average for elements with available scores = ______ Water Contact (WC)
______	(17)	Detention time	
______	(18)	Sheet vs. channel flow	
______	(19)	Average water depth	

$\frac{SS + V}{2}$ = ______ Wetland Characteristics (W)

If LF ≠ NA: $\frac{LF + W}{2}$ = ___/___ Wetland Condition (C)

If LF = NA: Wetland Condition (C) = W

$\frac{C + WC}{2}$ = ______ **Water Quality FCI**

Equation #8:

$$\frac{10b\ (10h + 10l)}{2}$$

PROJECT TITLE: ______________________________

WILDLIFE DATA SHEETS

Function weighting area (AREA) = Entire wetland assessment area

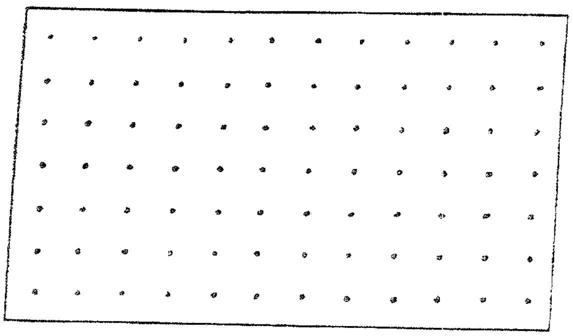
		For use in FCI Model		For use in Table A.2 only
		SELECTED SCORES FOR ELEMENTS		
ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	WAA	Planned Wetland	DIFFERENCE IN SCORES (Planned - WAA) If both are NA, record NA
Features which reduce habitat value (elements 4c, 16b, and 20a):				
4. Disturbance				
4c. Disturbance of wildlife habitat	[WL]*			Assume NA = 1.0
a. No or moderate disturbance.	NA			
b. Periodic disturbance used as wildlife management practice (e.g., controlled burning).	NA			
c. Evidence of recent (e.g., within last year) substantial periodic disturbance which reduces habitat availability (e.g., wetland tilled, filled, excavated, burned, or mowed).	0.1			
16. Size				
16b. Wetland site size				
Is the site considered to have a very low wildlife value because of its small size and poor conditions in or around the wetland (e.g., 1 ft. wide x 20 ft. long fringe marsh with access to other wetlands or upland wildlife habitat blocked by urban development)?	[WL]			Assume NA = 1.0
a. No.	NA			
b. Yes.	0.1			
If yes, explain: ______________________				

* Denotes function(s) to which element applies: SB = Shoreline Bank Erosion Control; SS = Sediment Stabilization; WQ = Water Quality; WL = Wildlife; FT = Fish (Tidal); FS = Fish (Stream/River); FP = Fish (Pond/Lake); and UH = Uniqueness/Heritage

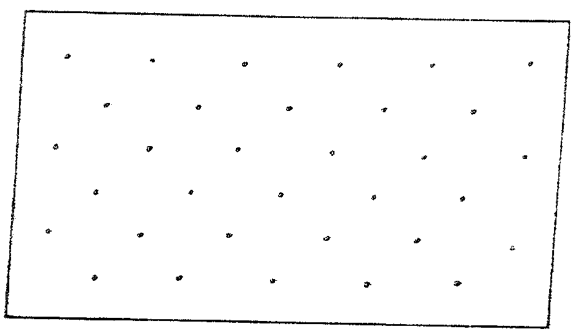
ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	SELECTED SCORES FOR ELEMENTS: WAA	SELECTED SCORES FOR ELEMENTS: Planned Wetland	DIFFERENCE IN SCORES (Planned - WAA) If both are NA, record NA
11b. Condition of layer coverage (**See Figure A.5**). (Consider canopy cover of each of the three vegetation layers: tree, midstory and herbaceous groundcover)	[WL]			
a. Approximately equal proportions and high percent cover (e.g., > 40%) for each layer.	1.0			
b. Intermediate condition.	0.7			
c. Predominantly 1 layer.	0.3			
d. Low percent cover for each vegetation layer.	0.1			
e. Predominantly unvegetated layer (e.g., open water, mudflat, bare ground, rock outcrop, and/or aquatic bed)	0.1			
11c. Spatial pattern of shrubs and/or trees (**See Figure A.6**)	[WL]			If one NA, record both scores.
a. No woody species -OR- few individual plants of woody species present (e.g., spatial pattern irrelevant for 2 trees).	NA			
b. Irregular (e.g., random, aggregate, or clumped distribution)	1.0			
c. Regular (e.g., uniform distribution, row planting, orchard).	0.1			
11d. Difference in layers	[WL]			Record both scores.
a. Planned wetland contains same layers as WAA.	NA	NA		
b. Planned wetland does not contain same layers as WAA.	1.0			
If answer "b", explain: ______				

REGULAR

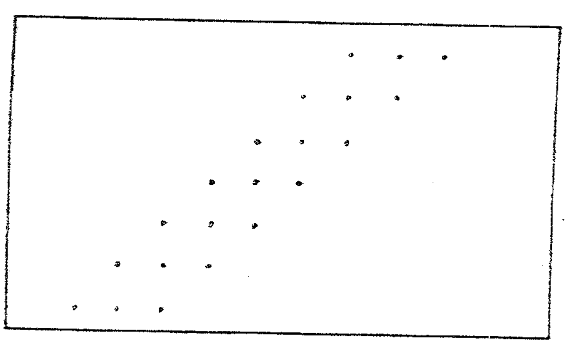
Uniform = Individuals are regularly spaced.



Uniform (row planting)

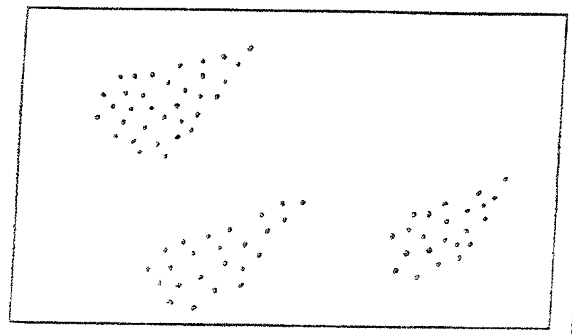


Uniform

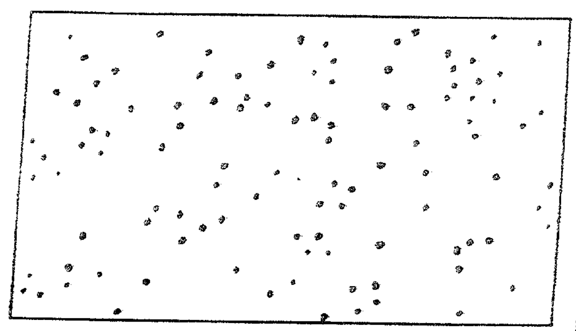


Uniform (rows)

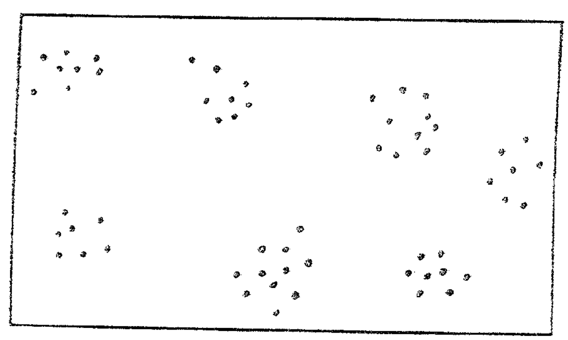
IRREGULAR



Aggregate Drifts or Sweep
(a cluster type grouping which tapers or feathers out along the edges.)



Random
(all individuals are located independently of each other.)



Clumped or Contagious Distribution
(individuals located together in clumps)

Figure A.6.
Examples of spatial patterns (element 11c)

Table A.3.
Description of Cover Types

Cover types based upon classification schemes of Cowardin et al. (1979) and Golet and Larson (1974). Definitions taken directly from Cowardin et al. (1979), unless otherwise indicated.

TREES. Woody vegetation that is 6 m (20 ft) or taller.

Needle-leaved evergreen. Areas dominated by woody gymnosperms with green, needle-shaped, or scale-like leaves that are retained by plants throughout the year. Examples:

black spruce	*Picea mariana*
Northern white cedar	*Thuja occidentalis*
Atlantic white cedar	*Chamaecyparis thyoides*

Broad-leaved evergreen. Areas dominated by woody angiosperms with relatively wide, flat leaves that generally remain green and are usually persistent for a year or more. Examples:

red mangrove	*Rhizophora mangle*
black mangrove	*Avicennia germinans*
white mangrove	*Laguncularia racemosa*
red bay	*Persea borbonia*
loblolly bay	*Gordonia lasianthus*
sweet bay	*Magnolia virginiana*

Needle-leaved deciduous. Areas dominated by woody gymnosperms with needle-shaped or scale-like leaves that are shed during the cold or dry season. Example:

bald cypress	*Taxodium distichum*

Broad-leaved deciduous. Areas dominated by woody angiosperms with relatively wide, flat leaves that are shed during cold or dry season. Examples:

black ash	*Fraxinus nigra*
red ash	*F. pennsylvanica*
American elm	*Ulmus americana*
black gum	*Nyssa sylvatica*
tupelo gum	*N. aquatica*
swamp white oak	*Quercus bicolor*
overcup oak	*Q. lyrata*
basket oak	*Q. michauxii*
red maple	*Acer rubrum*

Dead. Areas dominated by dead woody vegetation taller than 6 m (20 ft).

SCRUB-SHRUB. Area dominated by woody vegetation less than 6 m (20 ft) tall (including vines).

Tall evergreen.[*] Areas dominated by woody gymnosperms 3 to 6 m (10 to 20 ft) tall. Examples:

black spruce	*Picea mariana*
pond pine	*Pinus serotina*
young trees	(ex. *Rhizophora mangle* *Laguncularia racemosa* *Avicennia germinans*)

Bushy evergreen.[*] Areas dominated by woody gymnosperms 1.2 to 2 m (4 to 7 ft) tall. Examples:

sweet gale	*Myrica gale*
coastal sweetbells	*Leucothoe axillaris*
fetterbush	*Lyonia lucida*
inkberry	*Ilex glabra*

Low compact evergreen.[*] Areas dominated by woody gymnosperms less than 1.2 m (4 ft) tall. Examples:

sheep laurel	*Kalmia angustifolia*
bog laurel	*K. polifolia*
leatherleaf	*Chamaedaphne calyculata*
labrador tea	*Ledum groenlandicum*
bog rosemary	*Andromeda glaucophylla*
black ti-ti	*Cyrilla racemiflora*

Table A.3.
Description of Cover Types

(continued)

MOSS-LICHEN. Areas where mosses or lichens cover substrates other than rock and where emergents, shrubs, or trees make up less than 30% of the areal cover.

Moss. Areas dominated by mosses. Examples:

peat mosses	*Sphagnum* spp.
moss	*Campylium stellatum*
moss	*Aulacomnium palustre*
moss	*Oncophorus wahlenbergii*

Lichen. Areas dominated by lichens. Example:

reindeer moss	*Cladonian rangiferina*

AQUATIC-BED. Areas dominated by plants that grow principally on or below the surface of the water for most of the growing season in most years.

Rooted vascular. Areas dominated by rooted vascular plants that grow principally on or below the surface of the water for most of the growing season in most years. Examples:

turtle grass	*Thalasia testudinum*
shoalgrass	*Halodule wrightii*
widgeon grass	*Ruppia maritima*
wild celery	*Vallisneria americana*
eelgrass	*Zostera marina*
pondweed	*Potamogeton* spp.
naids	*Najas* spp.
water milfoil	*Myriophyllum* spp.
ditch grasses	*Ruppia* spp.
waterweed	*Elodea* spp.
yellow water lily	*Nuphar luteum*
water lilies	*Nymphaea* spp.
water smartweed	*Polygonum amphibium*

NON-VEGETATIVE.* Areas characterized by a lack of live vegetation cover.

Bedrock. Area characterized by a bedrock substrate covering 75% or more of the surface and less than 30% areal coverage of macrophytes.

Rubble. Area characterized by aerial cover with less than 75% bedrock, but stones and boulders alone, or in combination with bedrock, cover 75% or more of the surface.

Cobble-gravel. Area dominated by cobble and/or gravel. Cobbles are defined as rock fragments 7.6 cm (3 in) to 25.4 cm (10 in) in diameter. Gravel is a mixture composed primarily of rock fragments 2 mm (0.8 in) to 7.6 cm (3 in) in diameter; it usually contains sand.

Sand. Area dominated by sand. Sand is composed predominantly of coarse-grained mineral sediments with diameters larger than 0.074 mm and smaller than 2 mm.

Mud. Areas dominated by mud, i.e., wet soft earth composed predominantly of clay and silt-fine mineral sediments less than 0.074 mm in diameter.

Organic. Areas dominated by organic soil, i.e., soil composed of predominantly organic rather than mineral material.

Dead fallen trees/shrubs.* Area dominated by dead fallen trees and/or shrubs.

Open water. Water of any depth with no woody or emergent vegetation.

*Definitions modification of Cowardin et al. (1979) and Golet and Larson (1974).

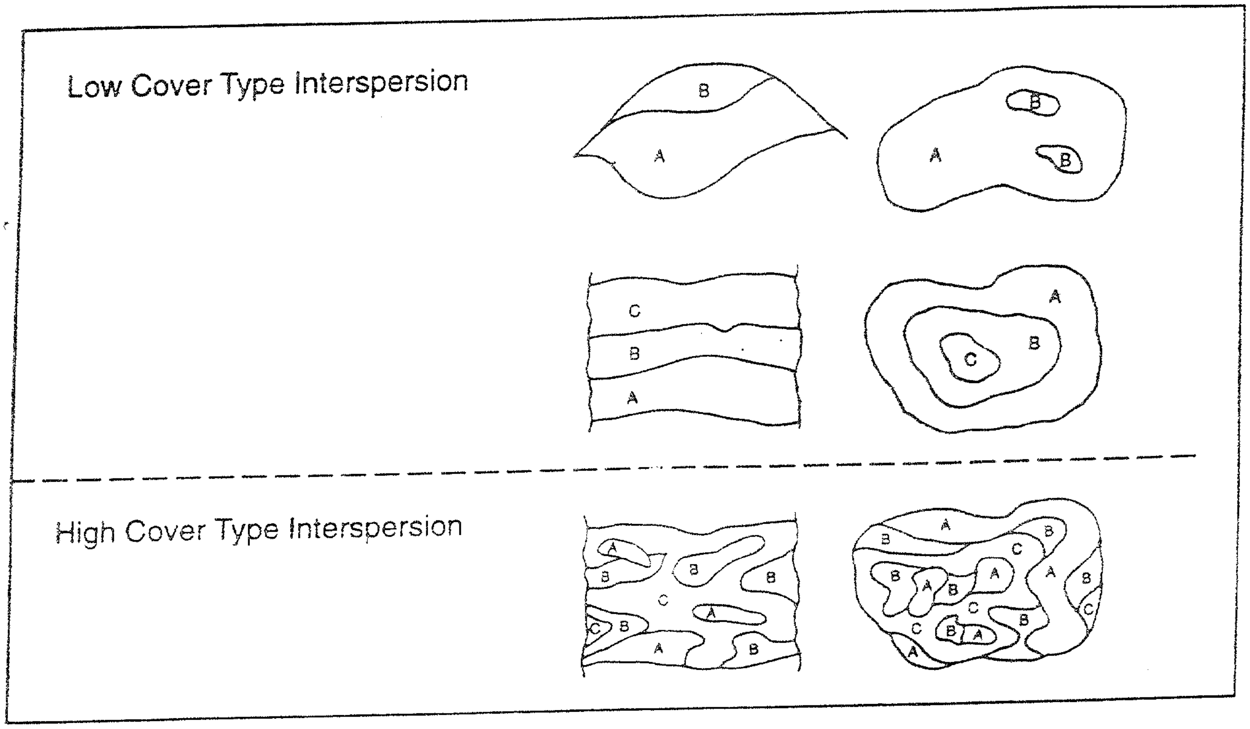


Figure A.8.
Cover type interspersion (element 12c)

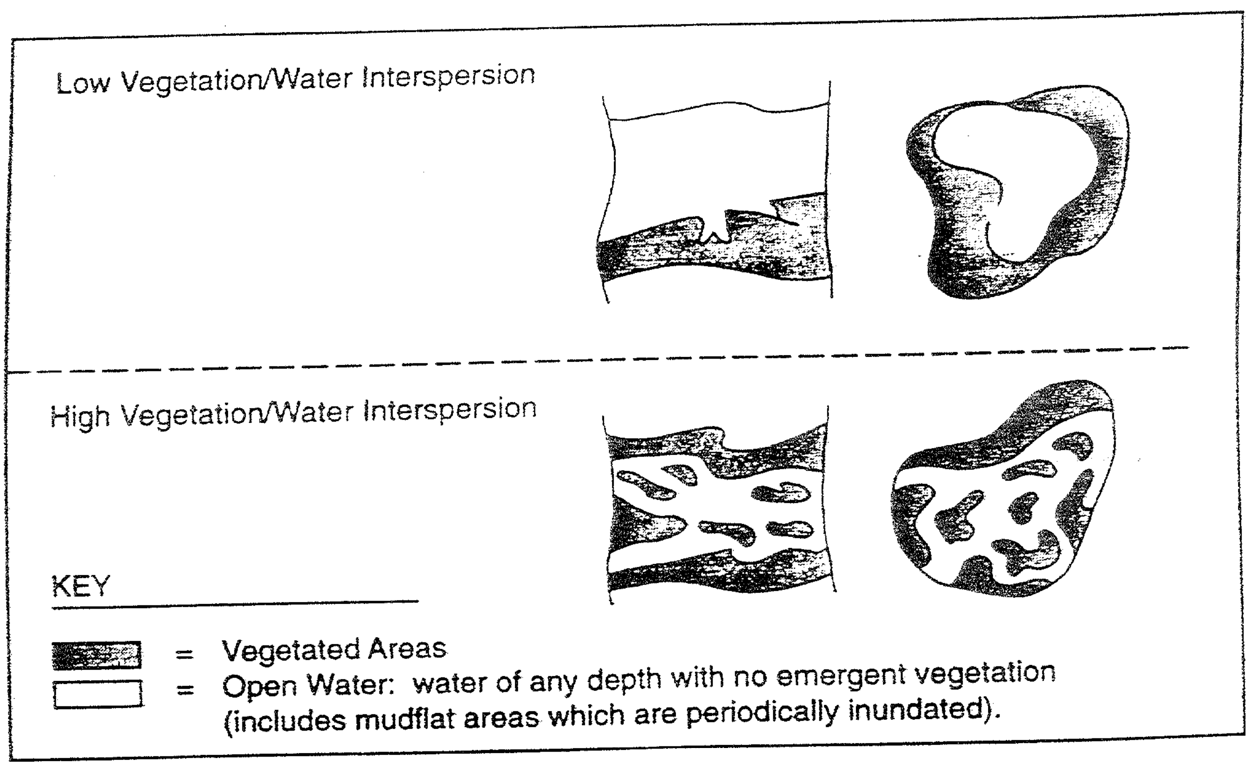


Figure A.9.
Vegetation/water interspersion (element 13b)

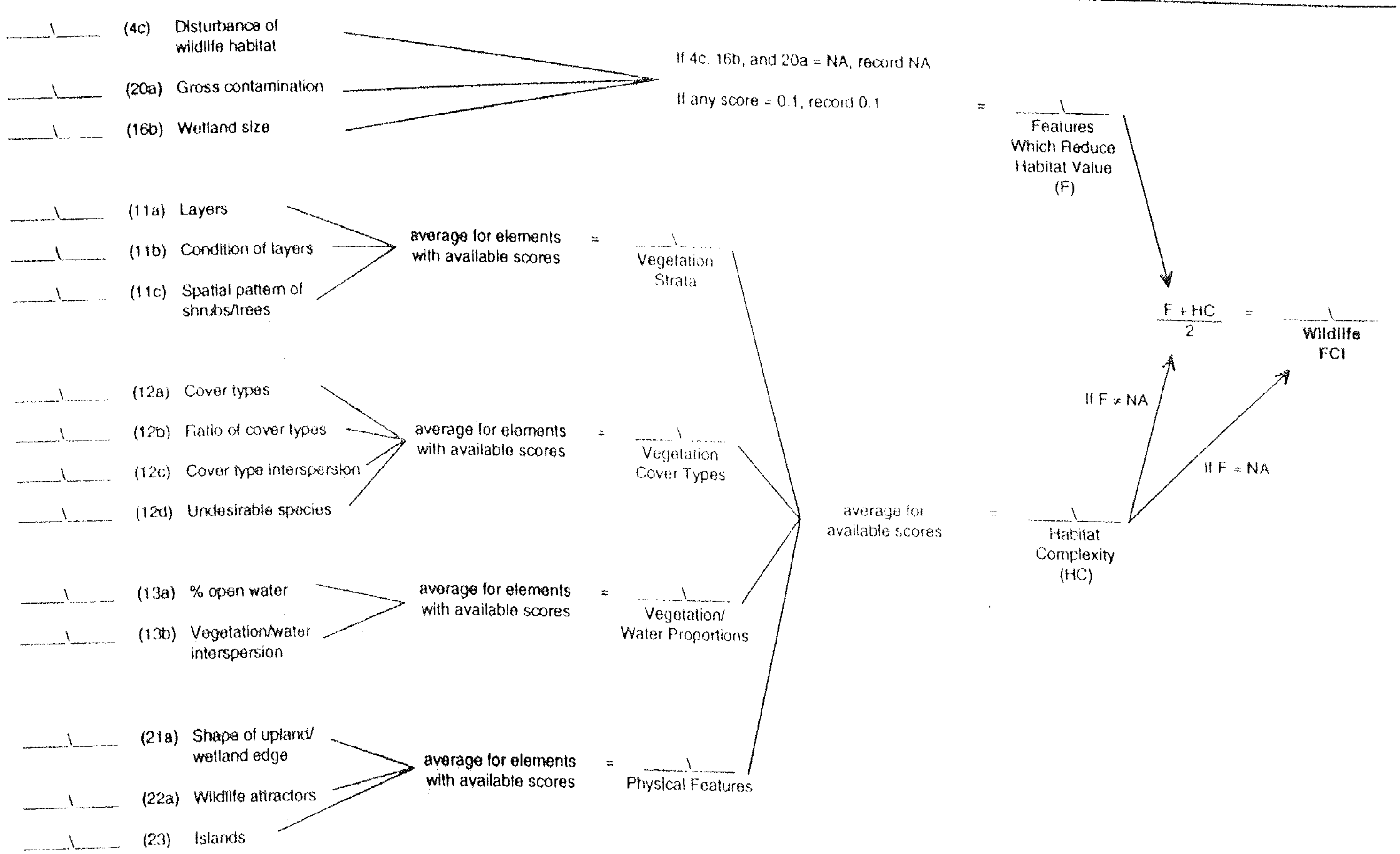
ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	SELECTED SCORES FOR ELEMENTS: WAA	SELECTED SCORES FOR ELEMENTS: Planned Wetland	DIFFERENCE IN SCORES (Planned - WAA) If both are NA, record NA
21. Shape of edge				
21a. Shape of upland/wetland edge **(See Figure A.10).** [WL]				
a. Upland/wetland edge absent.	NA			
b. Irregular.	1.0			
c. Regular, smooth.	0.1			
22. Fish and wildlife attractors (in wetland only)				Assume NA = 0
22a. Wildlife attractors [WL]				
Abundance of cover, other than live vegetation (e.g., snags, dense brush, fallen tree/logs, rocks/boulders, or artificial attractors).				
a. Absent or sparse.	NA			
b. Moderate to abundant.	1.0			
If present, check type of attractors and estimate percent cover. In some cases it may be best to count and record the number of attractors (e.g., nesting boxes).				
23. Islands [WL]				
a. Upland island(s) present.	1.0			
b. Upland island absent.	0.1			

Attractor	WAA	Planned Wetland
Snags	___	___
Dense brush	___	___
Brush piles	___	___
Fallen trees/logs	___	___
Rocks/boulders	___	___
Artificial:		
Nesting structures	___	___
Roosting sites	___	___
Artificial tree cavities	___	___
Other:__________	___	___

Calculation of WILDLIFE FCI

PROJECT TITLE: ____________________

Selected Scores | (#) | Element | COMPARISON: ________________ (e.g., WAA/planned wetland)



PROJECT TITLE: ______________________________

FISH (Tidal)
DATA SHEETS

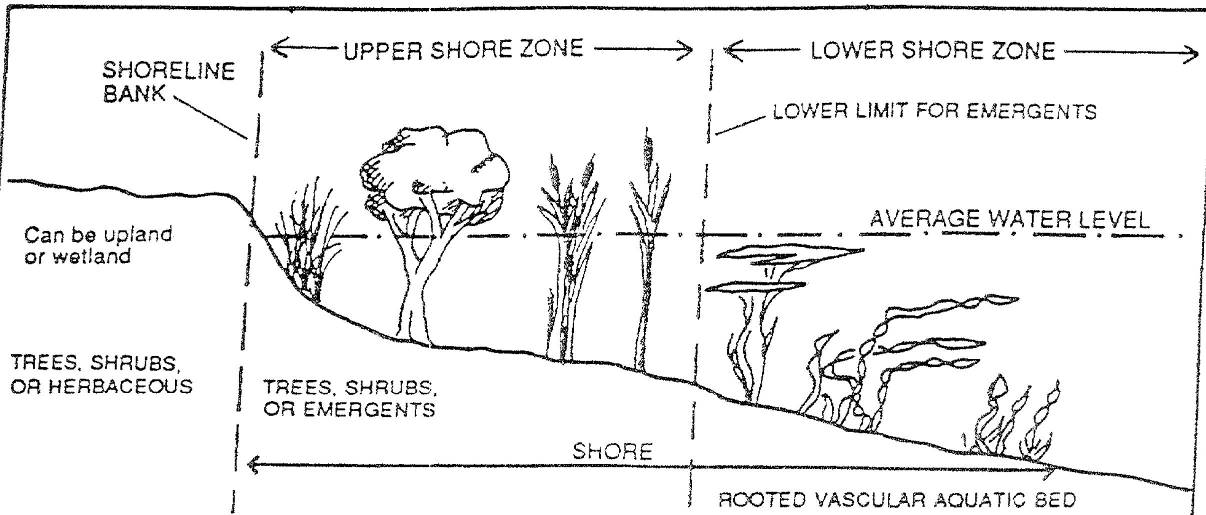
Function weighting area (AREA) = That portion of the assessment area which, based upon water regime, has the capacity to support tidal fish (e.g., tidally influenced areas up to line of spring high tides).

		For use in FCI model		For use in Table A.2 only
ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	SELECTED SCORES FOR ELEMENTS		DIFFERENCE IN SCORES (Planned - WAA) If both scores are NA, record NA
		WAA	Planned Wetland	
Suitability for tidal fish (element 24):				
24. Obstruction to on-site fish passage (obstruction can be on- or off-site)	[FT, FS, FP]*			Assume NA = 1.0
a. No barrier(s) present	NA			
b. Barrier(s) present, but conditions modified to permit fish passage (e.g., fish ladder, installation of culverts in mosquito control impoundments to re-establish tidal exchange and fish passage).	NA			
c. Barriers present, and utilized for fish management practices.	NA			
d. Site isolated, but utilized by fish (e.g., pond).	NA			
e. Condition(s) present which curtail fish passage (e.g., impingement on industrial intakes) or interfere with migratory cycles (e.g., semi-impoundment control structures such as weirs, undersized culvert).	0.5			
f. Condition(s) present which imposes absolute physical (e.g., impoundment for mosquito control, tide gate, dam, waterfall, thermal plume), chemical (extreme in pH), or behavioral barriers to fish passage. Fish access to the site and survival at site is precluded.	0.1			

If score for element 24 = 0.1, then there is no potential for providing the tidal fish function; therefore, the Fish (Tidal) FCI is not applicable (NA). Continue if scores = NA or 0.5.

* Denotes funtion(s) to which element applies: SB = Shoreline Bank Erosion Control; SS = Sediment Stabilization; WQ = Water

ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	SELECTED SCORES FOR ELEMENTS		DIFFERENCE IN SCORES (Planned - WAA) If both scores are NA, record NA
		WAA	Planned Wetland	
4d. Disturbance of channel/open water bottom (Open water = water of any depth with no emergent vegetation)	[FT, FS, FP]			Assume NA = 1.0
a. Channel/open water absent.	NA			
b. No or minimal recent disturbance.	NA			
c. Channel/open water disturbed in the past (e.g., dredged, channelized), but has begun to recover some of the natural channel/open water and shoreline characteristics (e.g., return to near original depths; and re-establishment of aquatic and shoreline vegetation, fallen trees, woody debris, and rocks).	0.5			
d. Channel/open water recently disturbed (e.g., filled, confined to culvert, or dredged in past year) -OR- substantially altered to prevent recovery of natural characteristics (e.g., cement channel)	0.1			
7. Hydroperiod				
7b. Most permanent hydroperiod	[FT]			Assume NA = 1.0
a. Natural tidal hydroperiod -OR- if the area is impounded, provisions have been made (e.g., culverts installed) so that hydroperiod mimics natural hydroperiod.	NA			
b. Hydroperiod usually follows natural tidal hydroperiod (e.g., hydroperiod periodically altered to manage for mosquito control).	0.5			
c. Hydroperiod does not or rarely follows natural tidal hydroperiod.	0.1			
24. Obstruction to on-site fish passage (Element already answered above.)				
Description of available food/cover (elements 7c, 9c, 10d, 10f, 21b, and 22b):				
7. Hydroperiod				
7c. Spatially dominant hydroperiod	[FT]			
a. Regularly flooded (e.g., low marsh).	1.0			
b. Both irregularly flooded and regularly flooded vegetated codominant (i.e., high and low marsh approximately equal proportions).	0.5			
c. Irregularly flooded (e.g., high marsh).	0.2			
d. Deep water (e.g., > 2 m at low tide).	0.1			



Shoreline Bank: Steep ascending slope of land of any height raised above the adjacent shore that can experience undercutting if it is in contact with water.

Shore: Vegetated or non-vegetated substrate located channelward of the bank.

Upper Shore Zone: Vegetated or non-vegetated portion of the shore located between the bank and the potential lower limit of emergent or woody vegetation as dictated by water depth or tide level.

Lower Shore Zone: Vegetated or non-vegetated portion of the shore located channelward of the potential lower limit of emergent or woody vegetation.

Entire Wetland: Includes wetland areas landward of the bank, the bank, the upper shore zone, and the lower shore zone.

Examples: Aerial View of Wetlands

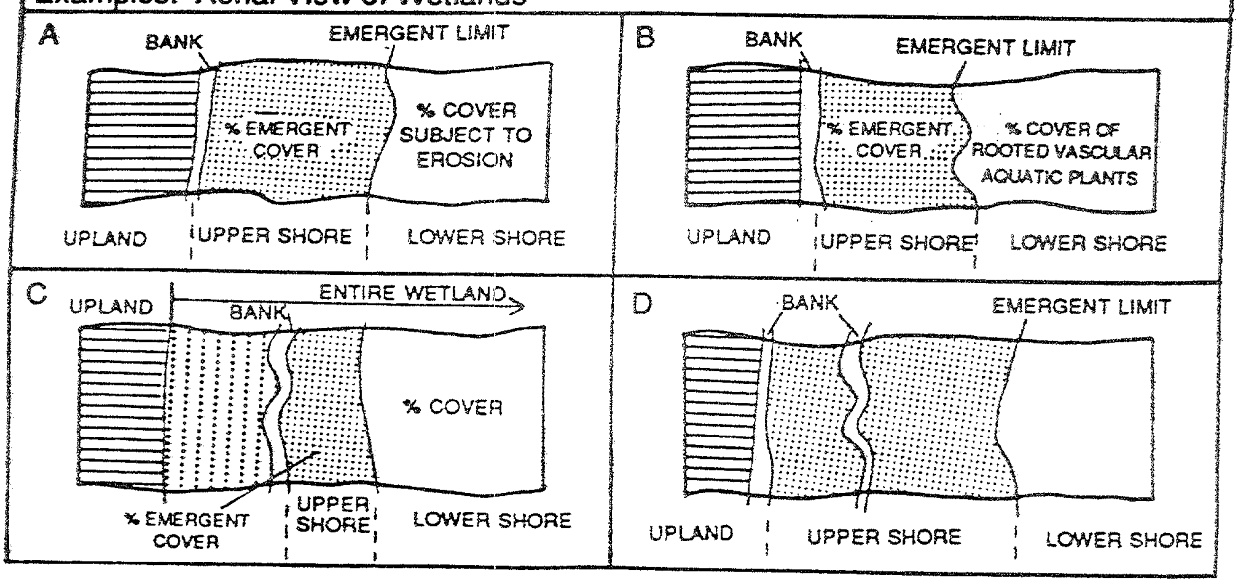
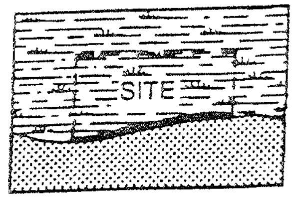
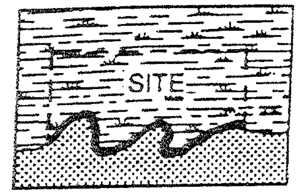


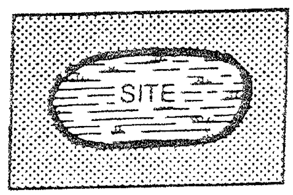
Figure A.2.

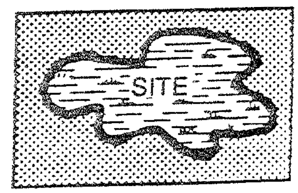
EDGE



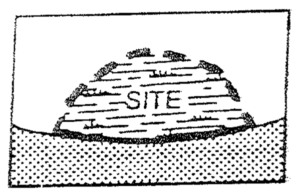


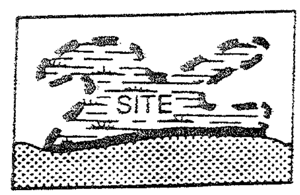
Upland/Wetland Boundary	Regular	Irregular
Wetland/Water Boundary	Absent	Absent



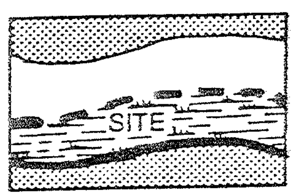


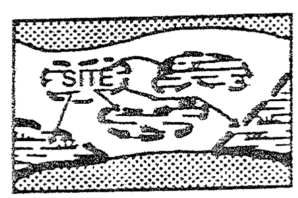
Upland/Wetland Boundary	Regular	Irregular
Wetland/Water Boundary	Absent	Absent





Upland/Wetland Boundary	Regular	Regular
Wetland/Water Boundary	Regular	Irregular





Upland/Wetland Boundary	Regular	Regular
Wetland/Water Boundary	Regular	Irregular

KEY:

- Upland/Wetland Edge (solid line)
- Wetland/Water Edge (dashed line)
- = Upland
- = Wetland
- = Open Water

Figure A.10.

ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	SELECTED SCORES FOR ELEMENTS		DIFFERENCE IN SCORES (Planned - WAA) If both scores are NA, record NA
		WAA	Planned Wetland	
Factors describing water quality (elements 20b, 20c, 20d, and 20f):				
20. Water quality				
20b. Water quality ratings	[FT, FS, FP]			If one INA, record both scores.
Define state water quality ratings and assign to following categories:				
High: ______________				
(e.g., Class A = no or minimal pollution)				
Moderate: ______________				
(e.g., Class B and C = moderate pollution)				
Low: ______________				
(e.g., Class D = severe pollution)				
Water quality rating for waterway				
a. Information not available.	INA			
b. High.	1.0			
c. Moderate.	0.5			
e. Low.	0.1			

Calculation of FISH (Tidal) FCI

PROJECT TITLE: ____________________

COMPARISON: ____________ (e.g., WAA/planned wetland)

Selected Scores	(#)	Element	
________	(24)	Obstruction to fish passage	If score = 0.1, STOP. There is no potential for providing tidal fish habitat. If score ≠ 0.1 or NA, then continue with model.
________	(1b)	Shoreline bank stability	average for elements with available scores = ________ Limiting Factors
________	(4a)	Disturbance at site (SS)	
________	(4d)	Disturbance in channel/open water	
________	(7b)	Most permanent hydroperiod	
________	(24)	Obstruction to fish passage	
________	(7c)	Spatially dominant hydroperiod	Equation #9 = ________ Food/Cover
________	(9c)	Substrate suitability for fish	
________	(10d)	Plant (basal) cover	
________	(10f)	Rooted vascular aquatic beds	
________	(21b)	Shape of wetland/water edge	
________	(22b)	Available fish cover/attractors	
________	(20b)	Water quality ratings	If score available, record score for WQ. If information not available, continue
________	(20c)	Nutrient/sediment/contaminant sources	average for elements with available scores = ________ Water Quality (WQ)
________	(20d)	Dissolved oxygen	
________	(20f)	Maximum water temperature	

Limiting Factors, Food/Cover, Water Quality (WQ): average for available scores = ________ Fish (Tidal) FCI

Equation #9:

$$\frac{7c\,[9c + (1-x)(10d) + (x)(10f) + 21b + 22b]}{4}$$

where x = portion of AREA which is represented by lower shore zone in increments of 0.1 (e.g., 0.1, 0.2, 0.3, ... 1.0)

PROJECT TITLE: ______________________________

FISH (Non-tidal Stream/River)
DATA SHEETS

Function weighting area (AREA) = That portion of the assessment area which, based upon water regime, has the capacity to support non-tidal stream/river fish. The period of inundation can vary throughout the site. Suitable wetland water regimes include permanently flooded, intermittently exposed, semipermanently flooded and seasonally flooded. Unsuitable water regimes may include saturated or intermittently flooded.

ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	For use in FCI model: SELECTED SCORES FOR ELEMENTS — WAA	Planned Wetland	For use in Table A.2 only: DIFFERENCE IN SCORES (Planned - WAA) If both scores are NA, record NA
Suitability for non-tidal stream/river fish (element 24):				
24. Obstruction to on-site fish passage (obstruction can be on- or off-site)	[FT, FS, FP]*			Assume NA = 1.0
a. No barrier(s) present.	NA			
b. Barrier(s) present, but conditions modified to permit fish passage (e.g., fish ladder, installation of culverts in mosquito control impoundments to re-establish tidal exchange and fish passage).	NA			
c. Barrier(s) present and utilized for fish management practices.	NA			
d. Site isolated, but utilized by fish (e.g., pond).	NA			
e. Condition(s) present which curtail fish passage (e.g., impingement on industrial intakes) or interfere with migratory cycles (e.g., semi-impoundment control structures such as weirs, undersized culvert).	0.5			
f. Condition(s) present which imposes absolute physical (e.g., impoundment for mosquito control, tide gate, dam, waterfall, thermal plume), chemical (extreme in pH), or behavioral barriers to fish passage. **Fish access to the site and survival at site is precluded.**	0.1			

NOTE: If score for element 24 = 0.1, then there is no potential for providing the non-tidal fish function; therefore, the FISH (Non-tidal Stream/River) FCI is not applicable (NA). Continue if scores = NA or 0.5.

* **Denotes function(s) to which element applies:** SB = Shoreline Bank Erosion Control; SS = Sediment Stabilization; WQ = Water Quality; WL = Wildlife; FT = Fish (Tidal); FS = Fish (Stream/River); FP = Fish (Pond/Lake); and UH = Uniqueness/Heritage

ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	SELECTED SCORES FOR ELEMENTS: WAA	SELECTED SCORES FOR ELEMENTS: Planned Wetland	DIFFERENCE IN SCORES (Planned - WAA) If both scores are NA, record NA
4d. Disturbance of channel/open water bottom (Open water = water of any depth with no emergent vegetation)	[FT, FS, FP]			Assume NA = 1.0
a. Channel/open water absent.	NA			
b. No or minimal recent disturbance.	NA			
c. Channel/open water disturbed in the past (e.g., dredged, channelized), but has begun to recover some of the natural channel/open water and shoreline characteristics (e.g., return to near original depths; and re-establishment of aquatic and shoreline vegetation, fallen trees, woody debris, and rocks).	0.5			
d. Channel/open water recently disturbed (e.g., filled, confined to culvert or dredged in past year) -OR- substantially altered to prevent recovery of natural characteristics (e.g., cement channel)	0.1			
16. Size				
16c. Fish habitat size	[FS, FP]			Assume NA = 1.0
Does the assessment AREA have a very low fishery habitat value because of (1) its small size and surrounding landscape (e.g., < 0.1 acre and bordered by urban development) or (2) because it is ephemeral.				
a. No.	NA			
b. Yes.	0.1			
If yes, explain: ______				
24. Obstruction to on-site fish passage (Element already answered above.)				
Description of available food/cover (elements 10m, 10o, 21b, 22b, 25a, and 26):				
10. Vegetation characteristics during growing season				
10m. Vegetative overhang (within 30 cm (1 ft) of water surface)	[FS,FP]			If one NA, record both scores.
Estimate optimum % overhang for this habitat type in region (e.g., > 50%): ______. Note abundance relative to this optimum.				
a. No shoreline on-site.	NA			
b. Abundant (e.g., > 1 ft. on 50% of shoreline).	1.0			
c. Moderate (e.g., > 1 ft. on 30 - 45% of shoreline).	0.5			
d. Sparse (e.g., > 1 ft. on less than 20% of shoreline).	0.1			

ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	SELECTED SCORES FOR ELEMENTS: WAA	SELECTED SCORES FOR ELEMENTS: Planned Wetland	DIFFERENCE IN SCORES (Planned - WAA) If both scores are NA, record NA
10o. Aboveground plant biomass in wetland, **excluding lower shore zone**	[FS, FP]			
a. Almost all potential aboveground plant biomass at present stage of development remains. Plant cover is close to that which would occur naturally without disturbance. If bare areas exist (e.g., bedrock), they are not a result of loss of vegetation from land uses.	1.0			
b. Plant biomass 50 - 75% of potential due to disturbance (e.g., grazing).	0.7			
c. Plant biomass 25 - 50%.	0.3			
d. Plant biomass < 25 (e.g., only root system and part of stems remain).	0.1			
21. Shape of edge				
21b. Vegetated wetland/water edge (e.g., shape of tidal creek or channel) (See Figure A.10).	[FT, FS, FP]			
a. Irregular.	1.0			
b. Regular, smooth.	0.5			
c. Edge absent or minimal (i.e., no channel in study wetland area).	0.1			
22. Fish and wildlife attractors				
22b. Available fish cover/attractors	[FT, FS, FP]			
Abundance of cover (e.g., vegetation, dense brush, fallen tree/logs, rocks/boulders, or artificial attractors) in littoral areas, pools, and backwaters during summer.				
Estimate potential cover for this habitat type in region (e.g., 25 - 75%): _________ Note abundance relative to this optimum.				
Warmwater fisheries:				
a. Optimal (e.g., 25 - 75%).	1.0			
b. Near optimal (e.g., 15 - 25% or 75 - 90%).	0.8			
c. Adequate (e.g., 3 - 15%) or excessive (e.g., 90 - 100%).	0.3			
d. No cover or sparse (e.g., < 3%).	0.1			
Trout stream:				
a. Optimal (e.g., 15 - 50%).	1.0			
b. Moderate (e.g., 2 - 15%).	0.5			
c. Excessive (e.g., > 50%).	0.1			
d. No cover or sparse (e.g., < 2%).	0.1			

(Element 22b continues on next page.)

ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	SELECTED SCORES FOR ELEMENTS: WAA	SELECTED SCORES FOR ELEMENTS: Planned Wetland	DIFFERENCE IN SCORES (Planned - WAA) If both scores are NA, record NA
26. Bank undercut	[FS]			If one NA, record both scores.
a. No shoreline on-site.	NA			
b. Bank undercut present and providing abundant cover for fish (e.g., undercut predominantly > 15 cm [> 6 inches]).	1.0			
c. Bank undercut present and providing moderate cover.	0.5			
d. Bank undercut minimal or absent (e.g., undercut predominantly < 15 cm [< 6 inches]).	0.1			
Factors affecting reproduction (elements 25b, 27a, and 27b)				
25b. Average current velocity over spawning areas during spawning and embryo development	[FS]			If NA and/or INA record both scores
Trout stream:				
a. Warmwater stream	NA			
b. No stream on-site	NA			
c. Information not available	INA			
d. 30 to 70 cm/sec (12 to 28 in/sec)	1.0			
e. 15 to 30 cm/sec (6 to 12 in/sec) -OR- 70 to 85 cm/sec (28 to 34 in/sec)	0.5			
f. < 15 cm/sec (< 6 in/sec) -OR- > 85 cm/sec (> 34 in/sec).	0.1			
27. Spawning habitat				
27a. Spawning substrate, **accessible during spawning periods.** Select *dominant* substrate.	[FS, FP]			
a. Gravel/rubble.	1.0			
b. Sand.	0.5			
c. Boulders, bedrock, _ fines (e.g., silt, mud, clay).	0.2			
d. Site not accessible during spawning.	0.1			
27b. Spawning structures	[FS,FP]			Assume NA = 0
a. Site not accessible during spawning.	NA			
b. Absent.	NA			
c. Present (e.g., gravel or rock spawning shoals, artificial reef, suspended platforms, spawning box).	1.0			
If present, describe: ____________________ ____________________				

ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	SELECTED SCORES FOR ELEMENTS: WAA	SELECTED SCORES FOR ELEMENTS: Planned Wetland	DIFFERENCE IN SCORES (Planned - WAA) If both scores are NA, record NA
20d. Dissolved oxygen (DO) during summer	[FT, FS, FP]			If one INA, record both scores.
Trout stream:				
a. Information not available.	INA			
b. Usually > 9 mg/l.	1.0			
c. Usually between 5 and 9 mg/l.	0.5			
d. Frequently < 5 mg/l.	0.1			
Warmwater stream:				
a. Information not available.	INA			
b. Usually > 5 mg/l.	1.0			
c. Usually between 2 and 5 mg/l.	0.5			
d. Frequently < 2 mg/l.	0.1			
20e. pH range	[FS, FP]			If one INA, record both scores.
Trout stream:				
a. Information not available	INA			
b. 6.5 to 8.0.	1.0			
c. Between 5.5 and 6.5 -OR- 8.0 and 9.0.	0.5			
d. ≤ 5.5 -OR- ≥ 9.0.	0.1			
Warmwater stream:				
a. Information not available.	INA			
b. 6.5 to 8.5.	1.0			
c. Between 5.0 and 6.5 -OR- 8.5 and 9.5.	0.5			
d. ≤ 5.0 -OR- ≥ 9.5.	0.1			
20f. Maximum mid-summer temperature within pools or littoral areas	[FT, FS, FP]			If one INA, record both scores.
Trout stream:				
a. Information not available.	INA			
b. 54 - 66° F (12 - 19° C).	1.0			
c. 36 - 54° F (2 - 12° C) -OR- 66 - 77° F (19 - 25° C).	0.5			
d. < 36° F -OR- > 77° F (< 2° C -OR- > 25° C).	0.1			
Warmwater stream:				
a. Information not available.	INA			
b. 68 - 86° F (20 - 30° C).	1.0			
c. 59 - 68° F (15 - 20° C) -OR- 86 - 93° F (30 - 34° C).	0.5			
d. < 59° F -OR- > 93° F (< 15° C -OR- > 34° C).	0.1			

Calculation of FISH (Non-tidal Stream/River) FCI

PROJECT TITLE: ____________________

Selected Scores	(#)	Element

COMPARISON ____________ (e.g., WAA/planned wetland)

______ (24) Obstruction to fish passage
→ If score = 0.1, STOP. There is no potential for providing stream/river fish habitat.
→ If score ≠ 0.1, then continue with model

Selected Scores	(#)	Element		
______	(1b)	Shoreline bank stability	average for elements with available scores =	______ Limiting Factors
______	(4a)	Disturbance at site (SS)		
______	(4d)	Disturbance in channel/open water		
______	(16c)	Fish habitat size		
______	(24)	Obstruction to fish passage		
______	(10m)	Vegetative overhang	average for elements with available scores =	______ Food/Cover
______	(10o)	Plant biomass		
______	(21b)	Shape of wetland/water edge		
______	(22b)	Available fish cover/attractors		
______	(25a)	% pool area		
______	(26)	Bank undercut		
______	(25b)	Current velocity within pools	average for elements with available scores =	______ Reproduction
______	(27a)	Spawning substrate		
______	(27b)	Spawning structures		
______	(20b)	Water quality ratings	→ If score available, record score for WQ → If information not available, continue	
______	(20c)	Nutrient/sediment/contaminant sources	average for elements with available scores =	______ Water Quality (WQ)
______	(20d)	Dissolved oxygen		
______	(20e)	pH		
______	(20f)	Maximum water temperature		
______	(20g)	Turbidity		

Limiting Factors, Food/Cover, Reproduction, Water Quality (WQ): average for available scores = ______ **Fish (Non-tidal Stream/River) FCI**

PROJECT TITLE: ______________________________

FISH (Non-tidal Pond/Lake) DATA SHEETS

Function weighting area (AREA) = That portion of the assessment area which, based upon water regime, has the capacity to support non-tidal pond/lake fish. The period of inundation can vary throughout the site. Suitable wetland water regimes include permanently flooded, intermittently exposed, semipermanently flooded and seasonally flooded. Unsuitable water regimes may include saturated or intermittently flooded.

		For use in FCI model		For use in Table A.2 only
ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	SELECTED SCORES FOR ELEMENTS		DIFFERENCE IN SCORES (Planned - WAA) If both scores are NA, record NA
		WAA	Planned Wetland	
Suitability for non-tidal pond/lake fish (elements 24 and 28):				
24. Obstruction to on-site fish passage (obstruction can be on- or off-site)	[FT, FS, FP]*			Assume NA = 1.0
a. No barrier(s) present.	NA			
b. Barrier(s) present, but conditions modified to permit fish passage (e.g., fish ladder, installation of culverts in mosquito control impoundments to re-establish tidal exchange and fish passage).	NA			
c. Barrier(s) present and utilized for fish management practices.	NA			
d. Site isolated, but utilized by fish (e.g., pond).	NA			
e. Condition(s) present which curtail fish passage (e.g., impingement on industrial intakes) or interfere with migratory cycles (e.g., semi-impoundment control structures such as weirs, undersized culvert)	0.5			
f. Condition(s) present which imposes absolute physical (e.g., impoundment for mosquito control, tide gate, dam, waterfall, thermal plume), chemical (extreme in pH), or behavioral barriers to fish passage. **Fish access to the site and survival at site is precluded.**	0.1			
28. Available refuge during drought and/or freeze Is there an accessible water body with areas of sufficient depth which will not dry up during a drought and/or freeze throughout the water column.	[FP]			Assume NA = 1.0
a. Yes.	NA			
b. No.	0.1			

NOTE: If score for element 24 and/or element 28 = 0.1, then there is no potential for providing the non-tidal fish function; therefore, the FISH (Non-tidal Pond/Lake) FCI is not applicable (NA). Continue if scores = NA or 0.5.

* Denotes function(s) to which element applies: SB = Shoreline Bank Erosion Control; SS = Sediment Stabilization; WQ = Water Quality; WL = Wildlife; FT = Fish (Tidal); FS = Fish (Stream/River); FP = Fish (Pond/lake); and UH = Uniqueness/Heritage

ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	SELECTED SCORES FOR ELEMENTS		DIFFERENCE IN SCORES (Planned - WAA)
		WAA	Planned Wetland	If both scores are NA, record NA
4d. Disturbance of channel/open water bottom (Open water = water of any depth with no emergent vegetation)	[FT, FS, FP]			Assume NA = 1.0
a. Channel/open water absent. disturbance.	NA			
b. No or minimal evidence of recent disturbance.	NA			
c. Channel/open water disturbed in the past (e.g., dredged, channelized), but has begun to recover some of the natural channel/open water and shoreline characteristics (e.g., return to near original depths, and re-establishment of aquatic and shoreline vegetation, fallen trees, woody debris, and rocks)	0.5			
d. Channel/open water recently disturbed (e.g., filled, confined to culvert, or dredged in past year) -OR- substantially altered to prevent recovery of natural characteristics (e.g., cement channel)	0.1			
16. Size				
16c. Fish habitat size	[FS,FP]			Assume NA = 1.0
Does the assessment AREA have a very low fishery habitat value because of (1) its small size and surrounding landscape (e.g., < 0.1 acre and bordered by urban development) or (2) because it is ephemeral.				
a. No.	NA			
b. Yes.	0.1			
If yes, explain: ______________________				
24. Obstruction to on-site fish passage (Element already answered above.)				

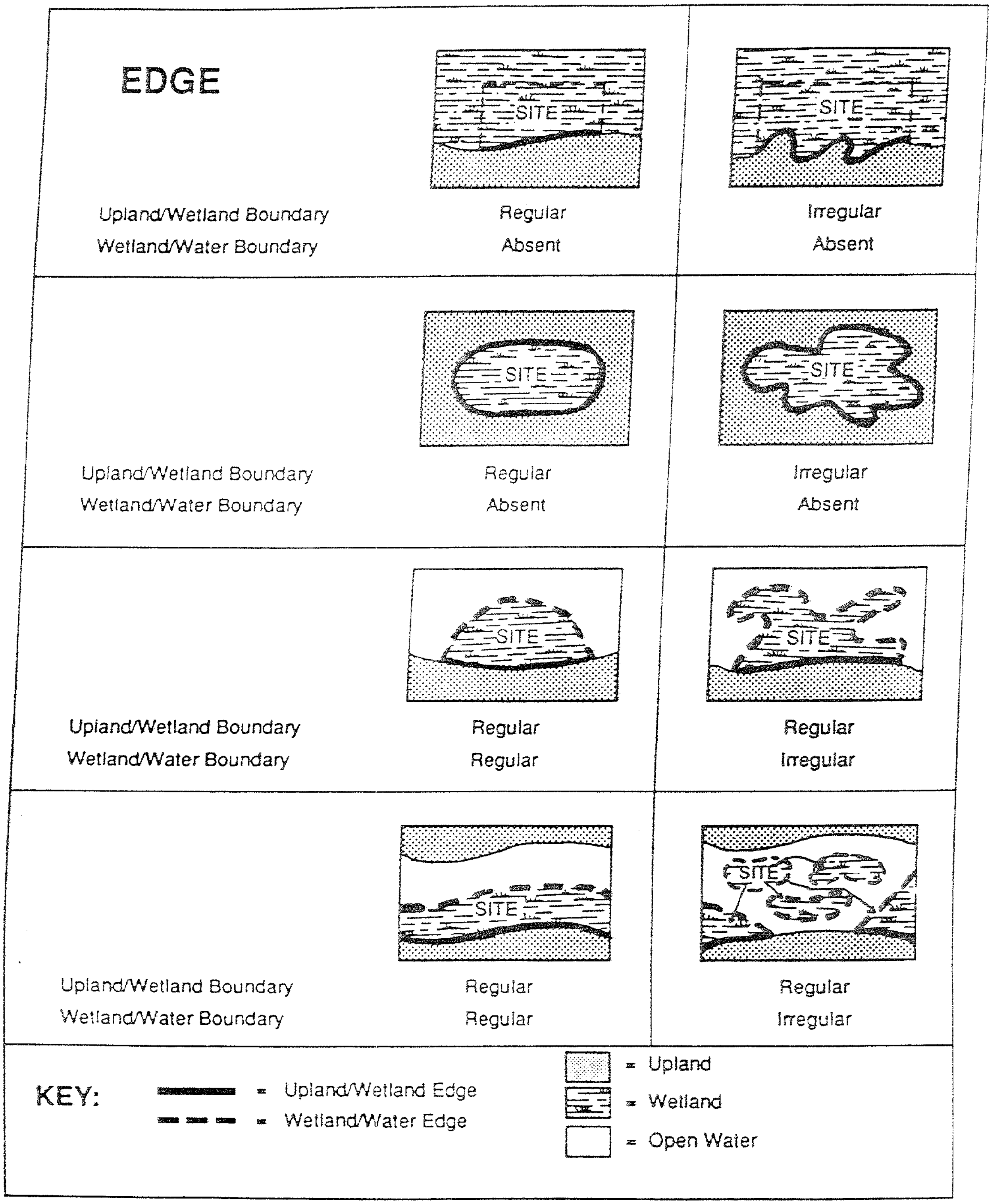

EDGE
SITE
SITE
Upland/Wetland Boundary
Wetland/Water Boundary
Regular
Absent
Irregular
Absent
SITE
SITE
Upland/Wetland Boundary
Wetland/Water Boundary
Regular
Absent
Irregular
Absent
SITE
SITE
Upland/Wetland Boundary
Wetland/Water Boundary
Regular
Regular
Regular
Irregular
SITE
SITE
Upland/Wetland Boundary
Wetland/Water Boundary
Regular
Regular
Regular
Irregular
KEY:
= Upland/Wetland Edge
= Wetland/Water Edge
= Upland
= Wetland
= Open Water

Figure A.10.

ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	SELECTED SCORES FOR ELEMENTS		DIFFERENCE IN SCORES (Planned - WAA) If both scores are NA, record NA
		WAA	Planned Wetland	
Factors affecting reproduction (elements 27a, 27b, and 27c):				
27. Spawning habitat				
27a. Spawning substrate, **accessible during spawning periods.** Select dominant substrate.	[FS,FP]			
a. Gravel and/or pebbles.	1.0			
b. Emergent and/or aquatic vegetation	1.0			
c. Sand and/or fine sediments (e.g., silt, mud, clay)	0.5			
d. Bedrock and/or boulders.	0.2			
e. Site not accessible during spawning	0.1			
27b. Spawning structures	[FS,FP]			Assume NA = 0
a. Site not accessible during spawning	NA			
b. Absent	NA			
c. Present (e.g., gravel or rock spawning shoals, artificial reef, suspended platforms, spawning box)	1.0			
If present describe ______________ ______________				
27c. Drawdown of water during spawning and embryo development (under normal conditions)	[FP]			Assume NA = 1.0
a. No or minimal drawdown	NA			
b. Moderate drawdown causing some loss of spawning habitat	0.5			
c. Drawdown sufficient to expose spawning substrate thus causing substantial loss of spawning habitat	0.1			
Examples of unsuitable drawdown levels gizzard shad >0.5 m (>1.6 ft) green sunfish >1 m (>3.3 ft) northern pike >1 m (>3.3 ft) black bullhead >2 m (>6.6 ft) longnose dace >3 m (>9.8 ft) largemouth bass >7 m (>23 ft)				

ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	SELECTED SCORES FOR ELEMENTS		DIFFERENCE IN SCORES (Planned - WAA) If both scores are NA, record NA
		WAA	Planned Wetland	
20c. Evidence of nutrient, sediment, or contaminant sources (If more than one score applicable, record lowest score).	[FT, FS, FP]			If one INA, record both scores.
a. Information not available.	INA			
b. Little or no potential for nutrient, sediment, or contaminant input.	1.0			
c. Evidence of or potential for moderate nutrient, sediment, or contaminant input.	0.5			
d. Evidence of high nutrient concentration in the wetland/waterway (e.g., recurrent algal blooms) or known source(s) contributing nutrients to the wetland/waterway (e.g., sewage outfalls, mine tailings, landfills, septic fields, active pasturelands and croplands).	0.1			
e. Evidence of high inorganic sediment input (e.g., stormwater outfalls, irrigation return flows; direct observation of sediment inputs, i.e., sediment plumes of turbid water at inlet; predominant soils/slopes classified as eroding or erosion hazard by SCS).	0.1			
f. Evidence of presence of contaminants (e.g., stunted plant growth, excessive growth, and/or abnormal morphology, oil sheen on marsh surface AND/OR known source(s) contributing contaminants to the wetland/waterway (e.g., hazardous water sites, superfund sites, landfills).	0.1			
g. Evidence of conditions known to stress fish (e.g., low DO, high turbidity, extremes in temperature, thermal plume).	0.1			
20d. Dissolved oxygen (DO) during summer	[FT, FS, FP]			If one INA, record both scores.
a. Information not available.	INA			
b. Usually > 5 mg/l.	1.0			
c. Usually between 2 and 5 mg/l.	0.5			
d. Frequently < 2 mg/l.	0.1			
20e. pH range	[FS, FP]			If one INA, record both scores.
a. Information not available.	INA			
b. 6.5 to 8.5.	1.0			
c. Between 5.0 and 6.5 -OR- 8.5 and 9.5.	0.5			
d. ≤ 5.0 -OR- ≥ 9.5.	0.1			

Calculation of FISH (Non-tidal Pond/Lake) FCI

PROJECT TITLE: ____________________

Selected Scores	(#)	Element

COMPARISON: ______ \ ______ (e.g., WAA/planned wetland)

________	(24)	Obstruction to fish passage
________	(28)	Refuge during drought/freeze

If score = 0.1 for either element, STOP. There is no potential for providing pond/lake fish habitat.
If score ≠ 0.1, then continue with model

________	(1b)	Shoreline bank stability
________	(4a)	Disturbance at site (SS)
________	(4d)	Disturbance in channel/open water
________	(16c)	Fish habitat size
________	(24)	Obstruction to fish passage

average for elements with available scores = ________ Limiting Factors

________	(10m)	Vegetative overhang
________	(10o)	Plant biomass
________	(21b)	Shape of wetland/water edge
________	(22b)	Available fish cover/attractors

average for elements with available scores = ________ Food/Cover

________	(27a)	Spawning substrate
________	(27b)	Spawning structures
________	(27c)	Drawdown

average for elements with available scores = ________ Reproduction

________	(20b)	Water quality ratings

→ If score available, record score for WQ
→ If information not available, continue

________	(20c)	Nutrient/sediment/contaminant sources
________	(20d)	Dissolved oxygen
________	(20e)	pH
________	(20f)	Maximum water temperature
________	(20g)	Turbidity

average for elements with available scores = ________ Water Quality (WQ)

Limiting Factors, Food/Cover, Reproduction, Water Quality (WQ): average for available scores = ________ **Fish (Non-tidal Pond/Lake) FCI**

PROJECT TITLE: ______________________

UNIQUENESS/HERITAGE
DATA SHEETS

Function weighting area (AREA) = Entire wetland assessment area

ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	For use in FCI Model: SELECTED SCORES FOR ELEMENTS — WAA	Planned Wetland	For use in Table A.2 only: DIFFERENCE IN SCORES (Planned - WAA) If both scores are NA, record NA
29. Endangered species (state- or federally-listed)	[UH]*			Assume NA = 0
a. Wetland not within known range of any threatened or endangered species	NA			
b. Wetland is known to be inhabited by threatened or endangered species	1.0			
c. Wetland is considered critical habitat for threatened or endangered species	1.0			
d. Wetland is within known range of threatened or endangered species, habitat suitable for these species.	0.9			
If answer b, c, or d selected, then note				
Species name(s) ______				
30. Site contains or is part of a wetland which is considered rare or uncommon in the region. (e.g., a wetland unlike others in the area with respect to size or vegetation type).	[UH]			Assume NA = 0
a. No.	NA			
b. Yes.	1.0			
If yes, fill out the following:				
Wetland type: ______				
Region/context: ______				

* Denotes function(s) to which element applies: SB = Shoreline Bank Erosion Control; SS = Sediment Stabilization; WQ = Water

ELEMENT	SELECTION OF SCORES FOR ELEMENT CONDITIONS	SELECTED SCORES FOR ELEMENTS: WAA	SELECTED SCORES FOR ELEMENTS: Planned Wetland	DIFFERENCE IN SCORES (Planned - WAA) If both scores are NA, record N
35. Site is owned by an organized conservation group or public agency for the primary purpose of preservation, ecological enhancement, or low-intensity recreation (e.g., park, scenic route, marine sanctuary).	[UH]			Assume NA = 0
a. No.	NA			
b. Yes.	1.0			
If yes, fill out the following: Group/Agency ______ Use: ______				
36. Site is known scientific research study site -OR- used for other educational purposes.	[UH]			Assume NA = 0
a. No	NA			
b. Yes	1.0			
If yes, explain ______				

Calculation of **UNIQUENESS/HERITAGE** FCI

PROJECT TITLE: ______________________

COMPARISON ______ \ ______ (e.g., WAA/planned wetland)

Selected Scores	(#)	Element
________	(29)	Endangered species
________	(30)	Rarity
________	(31)	Unique features
________	(32)	Historical or archaeological significance
________	(33)	Natural landmark
________	(34)	Connected to Wild and Scenic River
________	(35)	Park, sanctuary, etc.
________	(36)	Scientific research site

average for elements with available scores ________ Uniqueness/Heritage FCI

SMITH ISLAND ENVIRONMENTAL RESTORATION AND PROTECTION, MARYLAND

RECONNAISSANCE REPORT

MAY 1997

APPENDIX A

PLANNING AID REPORT
PREPARED BY USFWS

ENVIRONMENTAL RESTORATION AND PROTECTION OPPORTUNITIES ON SMITH ISLAND IN MARYLAND AND VIRGINIA

PLANNING AID REPORT

Prepared For:

Department of the Army
Baltimore District, U.S. Army Corps of Engineers
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Prepared By:

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Fish and Wildlife Biologists

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Chesapeake Bay Field Office
177 Admiral Cochrane Drive
Annapolis, Maryland 21401
March, 1997

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Introduction

The Baltimore District, U.S. Army Corps of Engineers is conducting a Reconnaissance Study to investigate the advisability of providing improvements on Smith Island, Somerset County, Maryland and Accomack County, Virginia, in the interest of navigation, flood control, erosion control, environmental restoration, wetlands protection, and other purposes. Smith Island is a complex of salt marsh islands separated primarily by narrow tidal creeks and shallow water areas. Smith Island is located in the Chesapeake Bay, approximately 12 miles west of Crisfield, Maryland and 95 miles south of Baltimore; it constitutes some of the most productive fish and wildlife habitat in the Chesapeake Bay.

This Planning Aid Report was prepared by the U.S. Fish and Wildlife Service to assist the Baltimore District in its assessment of natural resource issues for Smith Island. The report provides information on existing biological conditions, distribution of sensitive resources, potential environmental restoration opportunities, and recommendations for further study. It is submitted in accordance with the provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 *et seq*.) and the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq*.).

Study Area Description

Smith Island is located between Tangier Sound and the Chesapeake Bay (Figure 1). The western shore of the island is exposed to an open water fetch of 30 miles from the west, southwest, and northwest. Because of this exposed position, the overriding water resource related problems in the study area are flooding and erosion, which are further exacerbated by island subsidence. Although erosion, flooding, and subsidence constitute an obvious problem for people inhabiting the three towns on the island (Ewell, Rhodes Point, and Tylerton), important natural resources are also threatened.

The Hog Neck marsh peninsula is an example of the magnitude of the problem. Hog Neck emergent wetlands protect submerged aquatic vegetation beds occurring in Shanks Creek. Almost all the SAV beds at Smith Island are located within protected interior shallow waters or along the shoreline facing Tangier Sound. The western shoreline of the peninsula receded 2,000 feet between 1849 and 1968 (Maryland Geological Survey, 1975). Large acreages of vegetated wetlands and SAV are lost throughout Smith Island every decade (Harrison, pers. com.). Although the eastern shore of the island faces the more protected waters of Tangier Sound, erosion and sedimentation are still a problem in certain areas.

Biological resources in and around Smith Island are exceptionally rich and diverse. For this reason the northern half of Smith Island (encompassing approximately 4,000 acres) was acquired by the U.S. Fish and Wildlife Service, and now constitutes the Martin National Wildlife Refuge. With the exception of the three towns, several old dredged material disposal sites, and small dune hammocks, Smith Island is composed entirely of estuarine emergent wetlands bisected by numerous tidal creeks. The study area has a salinity range of 12 to 19 parts per thousand (Lippson, 1973), and a mean tidal range of 1.6 feet (Reed, 1997). Shallow waters within and surrounding the island support some of the most productive areas for SAV in Chesapeake Bay. These wetlands and aquatic beds in turn provide habitat for developing and mature species of fish, invertebrates, waterfowl, wading birds, shorebirds, raptors, railbirds, aquatic furbearers, terrapins, etc. Adjacent open waters support commercially important populations of crabs, oysters and clams, and commercially and recreationally important populations of finfish. The extent of these resources is examined in more detail below.

Habitat Types/Restoration Opportunities

Wetlands

Smith Island is primarily composed of estuarine wetlands of the following wetland classifications (Cowardin, *et al*. 1979):

- Estuarine, Intertidal, Emergent, Persistent
- Estuarine, Intertidal, Bar/Beach, Irregular Tidal
- Estuarine, Intertidal, Flat, Irregularly Exposed
- Estuarine, Intertidal, Flat, Regular Tidal
- Estuarine, Subtidal, Open Water (unknown bottom)
- Estuarine, Subtidal, Unconsolidated Bottom
- Estuarine, Subtidal, Aquatic Bed, Vascular

The dominant wetland species is black needlerush (*Juncus roemerianus*), with lesser amounts of smooth cordgrass (*Spartina alterniflora*), saltmeadow hay (*Spartina patens*), salt grass (*Distichlis spicata)*, marsh elder (*Iva frutescens*), groundsel bush (*Baccharis halimifolia*), saltmarsh bulrush (*Scirpus robustus*), waterhemp (*Amaranthus cannabinus*), and common reed (*Phragmites australis*). Common reed, an invasive wetland plant of relatively low wildlife value, is often associated with and dominates several old dredged material disposal sites on Smith Island.

Marsh areas are ecologically valuable not only for the habitat they provide for fish, birds, mammals, reptiles, and invertebrates, but also for their production and export of detritus. Detritus is a vital component of the aquatic food web, and estuarine energetics are associated with the linkage between wetland produced detritus and detritivores. Approximately two-thirds of the major U.S. commercially important fishes depend on estuaries and saltmarshes for nursery and spawning grounds (McHugh, 1966). Such wetland dependant species include menhaden (*Brevoortia tyrannus*), bluefish (*Pomatomus salatrix*), sea trout (*Cynoscion nebulosus*) spot (*Leiostomus xanthurus*), croaker (*Roncador stearnsi*), and drum (*Pogonias cromis*).

Smooth cordgrass, because of its position in the intertidal zone, is particularly valuable in terms of detrital export. Its occurrence on Smith Island is somewhat limited, and impacts to this vegetative community should be avoided. Of particular importance is a prominent stand of smooth cordgrass which lies immediately west of the southern tip of Rhodes Point. Wetland restoration efforts should prioritize this species. Because marshes are effective in deterring erosion, wetland restoration can also be used to protect fish, wildlife, and human habitats.

Uplands

The only upland areas are at the towns of Ewell, Tylerton, and Rhodes Point, and a few other isolated hammocks, dunes and former dredged material disposal areas. Vegetative communities found on the dune habitats are characterized by orache (*Atriplex patula*), Seaside goldenrod (*Solidago sempivirens*), saltmarsh fleabane (*Pluchea purpurascens*), sea rocket (*Cakile edunata*), American beach grass (*Ammophila breviligulata*), and switchgrass (*Panicum virgatum*). Although these areas have less direct benefit to the aquatic resources of the estuary, they are valuable habitats for avian, mammalian, and reptilian species, and also help buffer interior areas from erosion. Specific recommendations for protecting and promoting beach habitats can be found in the proceeding sections of this report.

Upland forested hammocks are important nesting sites for wading birds. Twelve hammocks on Smith Island currently contain wading bird rookeries. Generally these hammocks constitute isolated ridges surrounded by marsh and/or open waters, or are former dredged material disposal sites which are also adjacent to marsh and/or open water. Hammock vegetation is characterized by shrub and tree species such as wax myrtle (*Myrica cerifera*), groundsel bush, black cherry (*Prunus serotina*), sassafras (*Sassafras albidum*), and hackberry (*Celtis occidentalis*). Understory vegetation is comprised of vine species such as Japanese honeysuckle (*Lonicera japonica*), poison ivy (*Toxicodendron radicans*) and blackberry (*Ribes* spp.). An exception to the community described above are some of the old dredged material disposal sites. Several of these hammocks are primarily monotypic common reed. Restoration recommendations targeting the upland habitats are found in the Colonial Waterbird Section of this report.

Submerged Aquatic Vegetation

Smith Island remains one of the most productive areas for submerged aquatic vegetation in the Chesapeake Bay. Although the island has experienced some decline in this important habitat type, as shown in Figure 3.1 of the main report, Smith Island continues to exhibit extensive SAV beds compared to much of the Tangier Sound region (VIMS, 1994). Eel grass (*Zostera marina*) and widgeon grass (*Ruppia maritima*) are the dominant species, with widgeon grass occurring in waters generally less than 3 ft. deep MLW and eel grass occurring in waters greater than 3 ft. deep MLW but still within the photic zone. These grass beds are an important ecological component of the estuary. They provide cover and food for juvenile fishes, molting blue crabs (*Callinectes sapidus*) and many other crustaceans and mollusks, and are an important food for many species of waterfowl. The beds also support a locally based crab scrape fishery. As with the emergent wetlands, SAV beds contribute detritus to the estuarine food web. In addition to its direct value to fish and wildlife, SAV helps to stabilize bottom sediments and improve water quality. Almost all of the Smith Island SAV beds, or potential SAV habitat, are located within the protected interior shallow waters or along the shoreline facing Tangier sound.

The multi-agency Chesapeake Bay Program has produced a guidance document for protecting SAV (EPA, 1995). The document recommends the following:

- o Protect SAV and potential SAV habitat from physical disruption.
- o Avoid dredging, filling, or construction activities that create additional turbidity sufficient to impact nearby SAV beds during the SAV growing season (April 1 - October 31).
- o Establish an appropriate undisturbed buffer around SAV beds to minimize direct and indirect impacts on SAV from activities that significantly increase turbidity (500 yard buffer during the growing season).
- o Preserve natural shorelines. Stabilize shorelines, when needed, with marsh plantings as a first alternative. Use structures that cause the smallest increase in refracted wave energy where planting vegetation is not feasible (e.g. offshore breakwaters).
- o Educate the public about the potential negative effects of recreational and commercial boating on SAV, and how to avoid or reduce them.

Any Corps projects which result in improved water quality for the waters within and surrounding Smith Island will benefit SAV. Restoration and creation of SAV beds are not usually recommended to mitigate the loss of SAV through project impacts, as the technology to create or restore SAV beds generally has not proven successful over the long term. Outside the realm of compensatory mitigation, there may be opportunities to construct demonstration/experimental SAV restoration projects. Such an opportunity exists at Drum Point Island, northeast of the eastern approach to the Big Thorofare River.

A shoal occurring north of Drum Point Island provides wave protection to a large SAV bed north of Twitch Cove. Past winter storms have caused this shoal to migrate to the west; decreasing the amount of shallow water protected and covering portions of the existing SAV bed (Mike Harrison, pers. comm.). As an alternative to the previously used Twitch Cove open water placement site, dredged material from the Federal Navigation channel at Twitch Cove could be used to stabilize this shoal movement and restore addition acreage of SAV. Dredged-filled geotextile tubes or rirap breakwaters could be placed channelward of, and parallel to, the existing shoal. Dredged material capacity would dictate how far channelward of the existing shoal the tubes or breakwaters are deployed. After tube or breakwater placement, dredged material could be deposited between the existing shoal and tube or breakwater to an elevation which will support SAV.

Another possible cause for SAV declines in the interior reaches of Smith Island is the breaching of the heads of several tidal guts (Mike Harrison, pers. comm.). These breaches have allowed sediments from the open bay to accrete in the islands interior. The subsequent change in substrate type may be responsible for some SAV loss. These breaches are exacerbating island erosion. Projects aimed at closing the breaches would combat erosion, and might have a positive effect on SAV recolonization. In particular, the following areas should be targeted:

- Eroding shoreline north of Channel Point.
- Tidal gut parallel to Lighting Knot Cove.
- Tidal guts along Noah Ridge.
- Breaches around the jetties at the western approach to the Big Thorofare River.

If either the Drum Point Shoal or any of the breach closing projects are undertaken, a monitoring study to determine project success/failure should be developed. Monitoring data on SAV restoration is requisite to developing and improving techniques aimed at increasing this valuable Chesapeake Bay resource.

Fish and Wildlife Resources: Description and Restoration Opportunities

Endangered Species

Smith Island supports the Federally-listed endangered American peregrine falcon (*Falco peregrinus anatum*). Two nesting pairs occupy the Martin National Wildlife Refuge portion of the island, with both nests occurring on towers constructed for that purpose. One nest occurs on the north shore of Sawney Cove, and the other on the south shore of Joe's Ridge Creek. Nesting peregrines require tall nesting platforms in areas without significant human disturbance, and a readily accessible food source. Smith Island peregrines prey primarily on shorebirds and passerines. Habitat restoration projects benefiting these two bird guilds will also benefit the peregrine falcon.

Except for the peregrine falcon, and with the exception of occasional transient individuals, no other Federally-listed or proposed endangered or threatened species are known to exist on Smith Island. This relates only to endangered species under the jurisdiction of the U.S. Fish and Wildlife Service, and does not include State-listed species. Smith Island is within the range of several Federally-listed endangered species which could be transient visitors. Such species include the following:

Species	Status
bald eagle (*Haliaeetus leucocephalus leucocephalus*)	Threatened
arctic peregrine falcon (*Falco peregrinus tundrius*)	Endangered
red-cockaded woodpecker (*Picoides borealis*)	"
shortnose sturgeon (*Acipenser brevirostrum)*	"
leatherback turtle (*Dermochelys coriacea coriacea*)	"
hawksbill turtle (*Eretomochelys imbricata imbricata*)	"
Atlantic Ridley turtle (*Lepidochelys kempi*)	"
loggerhead turtle (*Caretta caretta caretta*)	Threatened
Atlantic green turtle *(Chelonia mydas mydas)*	"

Sea turtles feed on a variety of mollusks and crustaceans; for loggerheads the preferred prey is the horseshoe crab (*Limulus polyphemus*). Habitat restoration which improves mollusk and crustacean habitat may benefit transient sea turtles.

Invertebrates

The distribution of SAV is indicative of the value of the bottoms for benthic invertebrates. Although shallow water unvegetated substrate provides important habitat for many nekton species, this habitat has often been found to be relatively depauperate of benthic oriented epifauna as compared to vegetated shallow water habitat (Heck and Thoman, 1984; Fonseca *et al*., 1996). The protected interior shallow waters are likely to support a productive community of invertebrate species. Although some invertebrates have importance because of their commercial value, the ecological significance of most invertebrate communities lie in their contributions to the food web. They are a food source for fish, birds, reptiles, and mammals.

The aquatic habitat along the west shoreline of Smith Island is very different from the protected, stable interior areas. Bottoms along the west shoreline are exposed to heavy wave action due to the severe fetch. As the bottom is shallow (<4 ft.), storm events probably result in significant bottom scouring. Composition of bottom sediments is hard clay overlain with sand, which in not likely to support a diverse benthic infaunal community. Epibenthic and pelagic species would be expected to be more common.

The officially designated crabbing bottoms are displayed in Figure A-1. They correlate well with the areas which presently or historically supported SAV. As previously discussed, the submerged vegetation provides cover which is especially attractive to molting blue crabs. In addition, Tangier Sound is particularly important as a migratory route for juvenile blue crabs moving northward from spawning grounds in the lower Chesapeake Bay. The commercial harvest of blue crabs is a major source of income for the island residents. Smith Island is one of the most important soft-crab and peeler-crab producing areas in the Chesapeake Bay.

The general Smith Island/Tangier Sound area also support other commercial shellfish operations; including the harvest of oysters and clams. As with the rest of the Chesapeake Bay, oyster populations in the vicinity of Smith Island have been decimated by the oyster diseases MSX and Dermo. The nearest charted oyster bar, Church Creek, is located approximately 1.5 miles west of Rhodes Point. Restoration projects benefiting SAV, wetlands, and water quality in the Smith Island vicinity would also benefit commercially and ecologically important invertebrate resources, such as blue crab, clam and oyster.

Fish

The marshes of Smith Island are permeated with tidal creeks which provide spawning, nursery, and/or feeding habitat for an abundance of finfish. The contiguous waters of Chesapeake Bay and Tangier Sound also support extensive fishery stocks.

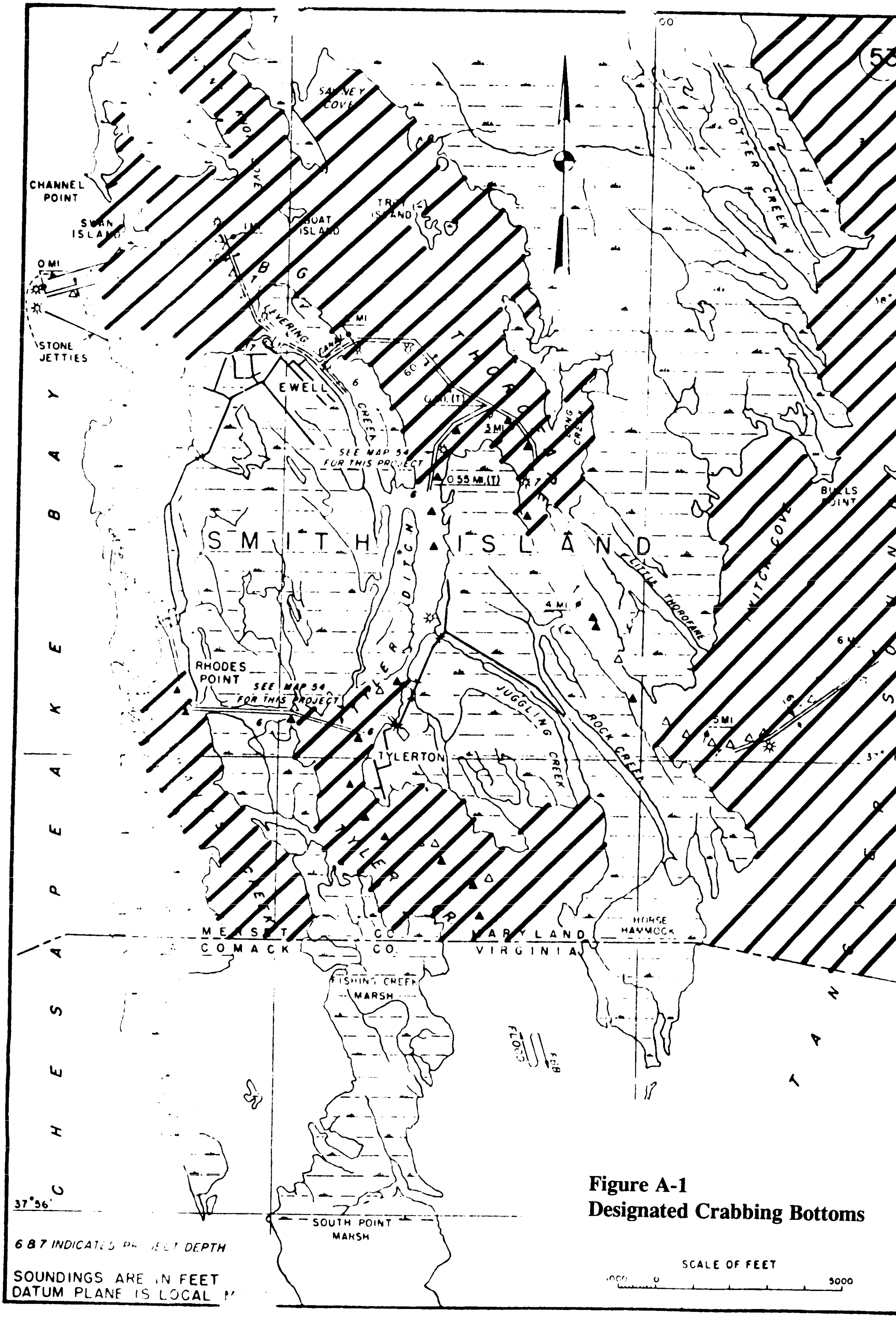

Figure A-1
Designated Crabbing Bottoms

Reported commercial fishery landings in Tangier Sound for 1992-1995, tabulated by the Maryland Department of Natural Resources, are provided in Table A-1. General location of the geographic area covered is shown in Figure A-2. It should be emphasized that these numbers only reflect commercially sought after species, and in no way reflects the recreational fishery. The Smith Island/Tangier Sound area does have a significant recreational fishery with sea trout, croaker, spot, bluefish, striped bass (*Morone saxatilis*), and summer flounder (*Paralichthys dentatus*) being commonly taken. In addition, this data base does not cover the interior waters of Smith Island, or the large diverse assemblage of forage species and shallow water species such as minnows, killifish, and silversides which are important prey items for the larger predatory species like the striped bass. As with the invertebrates, restoration projects benefiting SAV, wetlands, and water quality should also benefit the fishery resources within and around Smith Island.

Reptiles

Habitats/Threats

The diamondback terrapin (*Malaclemys terrapin*) inhabits salt and brackish waters of the Eastern United States, from Cape Cod south to the Gulf coast of Texas. In the Chesapeake Bay, terrapins utilize multiple habitats during the course of their life cycle. In late summer, the adult diamondback terrapin generally inhabits the deep portions of creeks and tributaries, avoiding nearshore waters. Juvenile terrapins inhabit shallow creeks and coves adjacent to salt marshes as nursery areas. During June and July, female terrapins cross the intertidal zone and seek nest sites in open sandy areas (Roosenburg 1991). Diamondback terrapins inhabit the tidal marshes and creeks of Smith Island, and are harvested by Smith Island inhabitants. The turtles have been observed nesting on the isolated upland hammocks of the Island complex.[1]

The diamondback terrapin is not listed as a Federal endangered species. It is a fishery resource in Maryland, and other states along the East coast. However, characteristics of terrapin life history render this species especially vulnerable to overfishing and habitat loss. These characteristics include: low reproductive rates, low survivorship, limited population movements, and nest site philopatry. This important Chesapeake Bay species utilizes several coastal habitat types that exist on Smith Island, which provides reasonable opportunities to protect and restore diamondback terrapin habitats through benficial use of dredged material.

Waterfront development has been demonstrated to directly reduce reproductive success in diamondback terrapins (Roosenburg 1991). Shoreline stabilization practices associated with near-shore development, such as wooden bulkheads, gabions, or rip-rap, prevent terrapins from reaching sites above the intertidal zone, the only viable terrapin nesting habitat. Because terrapins are philopatric (exhibiting a high degree of site fidelity) to nesting sites (Roosenburg 1992); “hard” shoreline stabilization practices may eliminate entire breeding colonies. Terrapins have

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[1] D.Jorde, PhD. Personal Communication, 1996, Patuxent Wildlife Research Center, USGS, Biological Resources Division, Laurel, MD.

1992-95 FINFISH LANDINGS IN TANGIER SOUND AND THE SOUTHERN CHESAPEAKE BAY

NOAACODE=092 SPECNAME=BLUEFISH, UNCLASSIFIED

OBS	YEAR	POUNDS
74	92	650
75	93	720
76	94	2083
77	95	4059

NOAACODE=092 SPECNAME=BUTTERFISH,UNCLASSIFIED

OBS	YEAR	POUNDS
78	92	202
79	93	40
80	94	3
81	95	47

NOAACODE=092 SPECNAME=CARP

OBS	YEAR	POUNDS
82	93	200
83	95	105

NOAACODE=092 SPECNAME=CATFISH

OBS	YEAR	POUNDS
84	92	115
85	93	98
86	94	436
87	95	3054

NOAACODE=092 SPECNAME=CRAPPIE

OBS	YEAR	POUNDS
88	93	412

NOAACODE=092 SPECNAME=CROAKER

OBS	YEAR	POUNDS
89	92	4308
90	93	29718
91	94	34359
92	95	176980

NOAACODE=092 SPECNAME=LINGOD

OBS	YEAR	POUNDS
110	94	16

NOAACODE=092 SPECNAME=MENHADEN, AT & GF

OBS	YEAR	POUNDS
111	95	48170

NOAACODE=092 SPECNAME=MULLET, BLACK OR SILVER

OBS	YEAR	POUNDS
112	95	35

NOAACODE=092 SPECNAME=PORGY, UNCLASSIFIED

OBS	YEAR	POUNDS
113	93	1445
114	94	75

NOAACODE=092 SPECNAME=SEA BASS, BLACK, UNCLASS

OBS	YEAR	POUNDS
115	92	147
116	93	757
117	94	66
118	95	92

NOAACOD =092 SPECNAME=SEA TROUT, GRAY, UNCLASS

OBS	YEAR	POUNDS
119	92	6630
120	93	14311
121	94	16473
122	95	5216

NOAACODE=092 SPECNAME=SPOT

OBS	YEAR	POUNDS
123	92	30145
124	93	41368
125	94	53388
126	95	48711

Table A-1

NOAACODE=092 SPECNAME=DRUM, BLACK

OBS	YEAR	POUNDS
93	92	60
94	94	62
95	95	132

NOAACODE=092 SPECNAME=DRUM, RED

OBS	YEAR	POUNDS
96	92	115
97	95	6

NOAACODE=092 SPECNAME=EEL, COMMON

OBS	YEAR	POUNDS
98	92	23819
99	93	13400
100	94	13175
101	95	8161

NOAACODE=092 SPECNAME=FLOUNDER, SUMMER

OBS	YEAR	POUNDS
102	92	696
103	93	1581
104	94	519
105	95	361

NOAACODE=092 SPECNAME=FLOUNDER,WINTER

OBS	YEAR	POUNDS
106	93	13

NOAACODE=092 SPECNAME=HALIBUT, UNCLASSIFIED

OBS	YEAR	POUNDS
107	92	80

NOAACODE=092 SPECNAME=HERRING

OBS	YEAR	POUNDS
108	93	225
109	95	10

NOAACODE=092 SPECNAME STRIPED BASS

OBS	YEAR	POUNDS
127	92	490
128	93	540
129	94	2608
130	95	2480

NOAACODE=092 SPECNAME=STRIPED BASS, RELEASED

OBS	YEAR	POUNDS
131	92	963
132	93	254
133	94	1217
134	95	958

NOAACODE=092 SPECNAME=SWELLFISH

OBS	YEAR	POUNDS
135	95	138

NOAACODE=092 SPECNAME=TAUTOG

OBS	YEAR	POUNDS
136	92	101

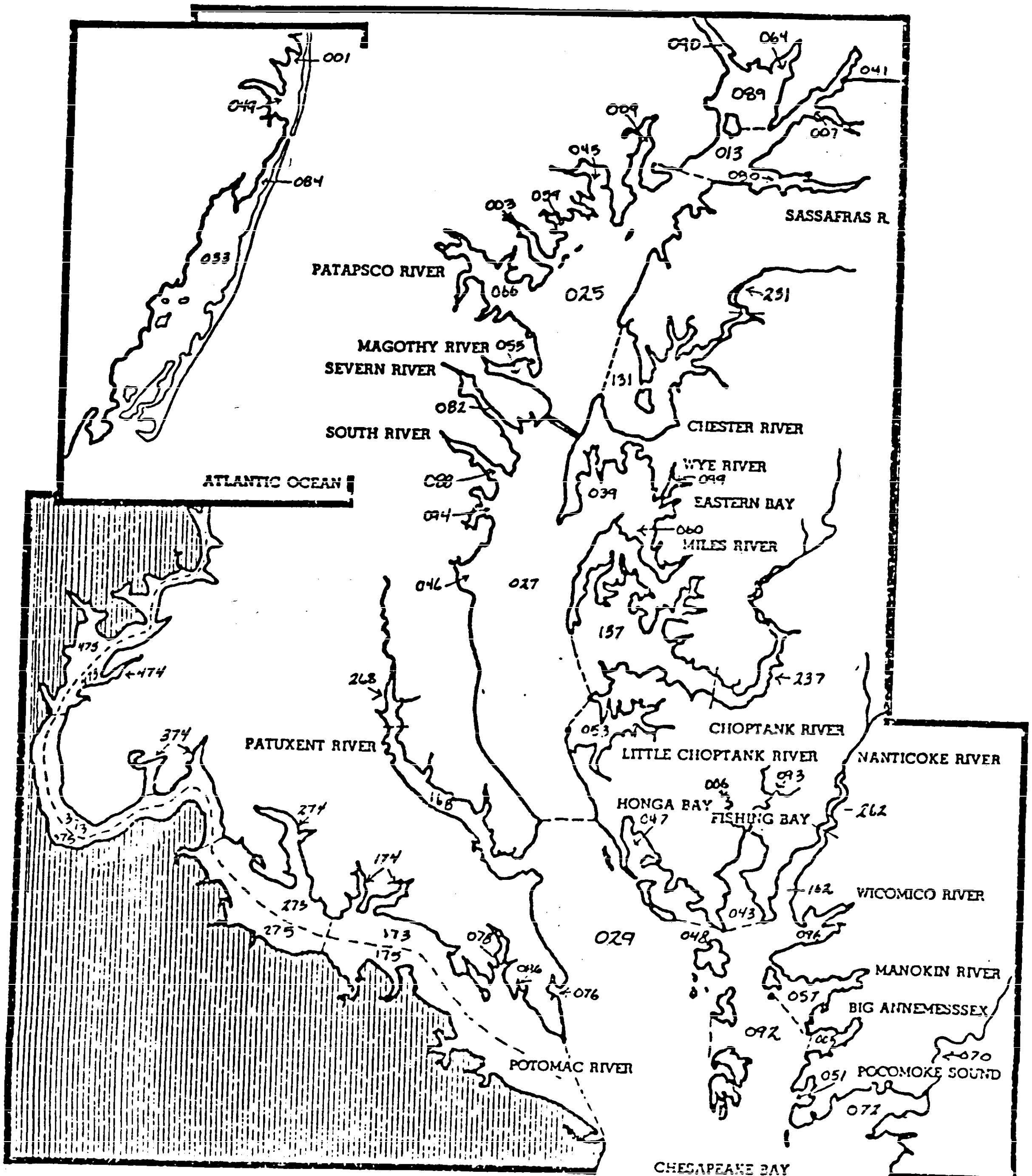
NOAACODE=092 SPECNAME=WHITE PERCH

OBS	YEAR	POUNDS
137	92	13130
138	93	15167
139	94	13258
140	95	20107

NOAACODE=092 SPECNAME=WHITING, UNCLASSIFIED

OBS	YEAR	POUNDS
141	92	58
142	93	22

Table A-1 (con't)



MD. CHESAPEAKE BAY NUMBERED COMMERCIAL FISHING AREAS–NOAA CODES

Figure A-2

assignments at a field office and at District headquarters been observed laying eggs in the sandy intertidal zone seaward of bulkhead structures - nests that are subsequently destroyed by high tides. Shoreline stabilization may also crowd nesting terrapins into smaller remaining habitats. Reduced numbers of viable breeding sites render terrapin populations more vulnerable to massive environmental disturbances, e.g. coastal flooding or disease. Crowding may also seriously decrease terrapin populations because predation rates are higher on nesting areas with higher nesting densities (Roosenburg 1990).

Other shoreline stabilization practices, e.g. beach grass planting, have been shown to destroy terrapin nests. Roosenburg (1991) documented that rhizomes of planted beach grass frequently penetrate terrapin eggs, killing the embryos. Lazell and Auger (1981) and Stegmann et al. (1988) found roots of these grasses surrounding nests, using the eggs as a source of nutrients and killing the embryos, or entangling hatchlings, which subsequently die underground. In addition, as beach grasses colonize more beach foredune area, less open sandy area is available for terrapin nests.

Raccoons are a primary predator of terrapin eggs (Roosenburg 1991). Red fox also are significant predators.[2] Shoreline development may contribute to increased numbers of raccoons and foxes that are well-adapted to human encroachment. Increases in these species likely places greater demands upon prey items, such as turtle eggs.

The recreational and commercial crab fishery in the Chesapeake Bay presents a serious threat to the diamondback terrapin. The traditional 2ft.x2ft.x2 ft. wire crab pot used in the Bay captures terrapins (Bishop 1983; Roosenburg 1992). Juvenile and male terrapins, by virtue of their smaller size, are the most frequently caught. Because the pots are deployed in the subtidal zone for extended periods of time, the captured terrapins drown.

The commercial diamondback terrapin fishery in the Chesapeake Bay also presents a significant, potential threat to the species. Studies on terrapins in the Potomac River have shown the species to have low reproductive rates (est. 39 eggs/yr.) and low survivorship (1% to 3% of eggs to hatchlings; hatchling to adult - unknown) (Roosenburg 1992). Current terrapin harvest regulations in Maryland restrict harvest to individuals of a minimum plastron length of 6 inches. This size restriction targets reproductive females, placing diamondback terrapin recruitment at greater risk.

Restoration/Protection Opportunities

Sandy substrates are important dianmondback terrapin breeding areas, compared to other habitat types. For example, terrapin eggs taken from an eroding clay bank, abutting a sandy intertidal substrate, were found to be inviable because clay particles clog pores in the eggs, and inhibit gas exchange (Roosenburg 1994). Nests are generally above the reach of normal high

[2] **G.M. Haramis and D. Jorde, Personal Communication, 1996, Patuxent Wildlife Research Center, USGS, Biological Resources Division, Laurel, MD.**

tides, such as on elevated sand dunes (Siegel 1984; Auger and Giovannone 1979) or on the high, foredune area. Typically, nesting areas are closely associated with extensive salt marsh and lagoon systems, which provide habitats for adult terrapins (Roosenburg 1994). On the Patuxent River, Roosenburg found that terrapin nesting density was higher on open, sparsely vegetated beaches that were isolated from the mainland by saltmarsh. Although infrequent, wind-driven high tides occasionally flooded the nests, Roosenburg reported that the embryos could frequently survive intermittent inundation depending upon the stage of incubation and duration of flooding. Lovich et. al. (1991) discovered that artificially incubated, released terrapin juveniles avoid open water, and instead seek out and burrow into tidal wrack habitat. Burger (1977) reported that hatchlings move toward the closest terrestrial vegetation, and Pitler (1985) observed juveniles hiding under accumulated surface debris and matted *Spartina* sp. Lovich et. al. (1991) proposed that young terrapins utilize wrack for cover, moist conditions, cooler temperatures, and small invertebrate foods, such as small crabs, amphipods, and insects.

Base on these studies, creating potential diamondback terrapin nesting habitat through beneficial use of dredged material on Smith Island is feasible. Terrapin habitat projects could be dove-tailed with creation of breeding habitat for terns, skimmers and oystercatchers (see colonial waterbird section of this report). Sandy material should be placed along shorelines at highly isolated points around the island complex, and mounded into high dune areas or elevated marsh ridges. Placement sites should be at elevations 6-8m above the high tides, and should be protected from erosion using geotextile tubes or other erosion barriers, to assure long-term availablity of breeding habitat. Sites should not be planted with native dune grasses, which will reduce the potential as breeding habitat for terrapins, and terns and skimmers. Any shoreline placement sites on Smith Island should be adjacent to saltmarsh and shallow estuarine waters to provide habitat for terrapin adults.

Studies suggest that diamondback terrapins exhibit limited movements, and that populations are restricted to small, discrete areas within the Bay (Roosenburg 1992). This factor, combined with the philopatric tendencies of the species, may indicate that it will take a long period of time for populations to establish nesting areas on newly-created sites. However, sandy substrates above the reach of high tides are rare on Smith Island, and many of these areas are eroding. Created beach habitats may provide a limited and declining nesting substrate.

U.S. Fish and Wildife Service personnel and biologists from the Patuxent Wildlife Research Center[3] have observed female diamondback terrapins aggregating on the upland hammocks on Smith Island during the breeding season. Because unvegetated, high sandy substrates are limited at Smith, the biologists conclude that it is likely that terrapins use these marsh islands as nesting sites. No studies on the productivity of terrapins on these islands have

[3] **D.Jorde, PhD. Personal Communication, 1996, Patuxent Wildlife Research Center, USGS, Biological Resources Division, Laurel, MD.**

been conducted. However, the likelihood of use of these hammocks by diamondback terrapins, coupled with the value of these sites as breeding areas for colonial waterbirds and waterfowl, and staging areas for migrating neotropical landbirds, underscores the need to permanently protect them.

Other reptile species occurring on Smith Island include: box turtle (*Terrapene carolina carolina*), northern water snake (*Natrix sipedon*), and rough green snake (*Opheodrys aestivus*). These species are not currently perceived as threatened or declining in Maryland.

Colonial Waterbirds - Waders

Populations/Habitats

The coastal plain is the most important physiographic region in Maryland for breeding colonial waterbirds. Chesapeake Bay islands within this region provide particularly important habitats for bird colonies. According to state surveys, in 1995, Somerset County contained 20% of the state's total colonial waterbird colonies and 23% of the total breeding pairs (Brinker et al. 1996). Smith Island has one of the highest numbers of colonial waterbird colonies-per-area in the state; twelve active breeding colonies for wading birds were recorded there in 1995. Five species of heron, three species of egret, and glossy ibis breed at Smith Island according to state surveys (see Table A-2). This census does not include green herons, which have also been recorded as breeding on Smith Island (Armistead 1974).

Brinker et al. (1996) reported that four of the nine species of wading birds that breed at Smith Island have shown significant declines in Maryland between 1985 and 1995 (snowy egret, tricolored heron, black-crowned night heron, and glossy ibis). Declines for these species may be the result of a variety of factors, including habitat disturbance or loss, altered prey bases, increases in competing species, increases in predators, or exposure to contaminants. Because colonial waterbirds concentrate reproductive efforts at a few, discrete locations, these populations are particularly sensitive to habitat disturbance or loss. The Maryland population of glossy ibis has declined by approximately 50% since 1985 - primarily attributable to a major disturbance at the Point Comfort colony on Smith Island. The Maryland Department of Natural Resources, Wildlife and Heritage Division has placed a high priority upon protection from human disturbance and erosion for colonial waterbird rookeries (Brinker et al. 1996).

Rookeries at Smith Island are located on isolated ridges surrounded by marsh (*hammocks)*, vegetated primarily with woody shrubs, i.e. wax myrtle (*Myrica cerifera*), groundsel tree (*Baccharis halimifolia*), and marsh elder (*Iva frutescens*), trees, i.e. black cherry (*Prunus serotina*), sassafras (*Sassafras albidum*), and hackberry (*Celtis occidentalis*), and vines, i.e. japanese honeysuckle (*Lonicera japonica*), poison ivy (*Toxicodendron radicans*), and blackberry (*Ribes* spp). Hammocks are generally small sites (1-20 acres), isolated from larger land masses by extensive tracts of black needlerush (*Juncus roemerianus*) marsh and tidal creeks. Some hammocks are topographic high points in the landscape that have become isolated due to land subsidence and sea level rise; others are dredged material disposal areas that were originally, in part, tidal marsh.

There are approximately 12 hammocks on Smith Island that currently contain important wading bird rookeries. Three of these areas, Cherry Island, Wellridge Creek, and Lookout Tower are part of Martin National Wildlife Refuge. The other areas are privately owned wooded islands scattered across the southern half of Smith Island, south of the Big Thoroughfare navigation channel.

Table A-2. Colonial waterbirds breeding at Smith Island according to Brinker et al. (1996) and the Maryland Department of Natural Resources, Division of Forestry, Wildlife and Heritage.[4]

Species Common Name	Scientific Name	Status
Glossy Ibis	***Plegadis falcinellus***	tracked as rare by MDNR; declining trend 1985-1995
Great-blue Heron	***Ardea herodias***	
Great Egret	***Casmerodius albus***	
Snowy Egret	***Egretta thula***	declining trend 1985-1995
Tricolored Heron	***Hydranassa tricolor***	declining trend 1985-1995
Little Blue Heron	***Egretta caerulea***	tracked as rare by MDNR
Cattle Egret	***Bubulcus ibis***	
Black-crowned Night-heron	***Nycticorax nycticorax***	declining trend 1985-1995
Yellow-crowned Night-heron	***Nyctanassa violacea***	

Threats

Wooded island habitats in the Chesapeake Bay, exposed to little disturbance by humans or mammalian predators, provide important breeding sites for migratory birds such as colonial waterbirds (Erwin and Spendelow 1991), waterfowl and certain raptors. These sites also provide important resting and staging areas for migratory songbirds. Habitats for many of these species have been severely limited on the mainland surrounding the bay because of development, human disturbance, cultivation, and exposure to predation by domestic animals.

Recent studies have demonstrated that erosional loss of Chesapeake Bay island habitats has accelerated during the last century, due to sea-level rise and land subsidence (Wray et al. 1995, Kearney and Stevenson 1991). Recent studies on three wooded islands in the Chesapeake Bay - Barren, James, and Poplar Islands - suggest that these habitats are eroding along western shorelines at an average rate of 4.96 m/yr ±0.12 (Wray et al. 1995). Erosion on eastern shore islands in the middle portion of the Bay (Galenter 1990) has reduced nesting habitats, which has a

4 J.McKnight, Personal Communication, 1996, Maryland Department of Natural Resources, Division of Forestry, Wildlife and Heritage, Heritage and Biodiversity Conservation Resource Management Team, Annapolis, Maryland.

negative impact on colonial waterbirds, waterfowl, and migratory songbirds. Habitat loss for wading birds breeding in the bay region increases risks of predation, disease, and natural disasters (storm events, oil spills, etc.) (Erwin and Spendelow 1991). Waterfowl researchers have correlated the loss of isolated islands, along with increased shoreline development, with the decline of black ducks in the Chesapeake Bay (Krementz et al. 1991).

Erosion poses the greatest threat for waterbird colonies on Smith Island. For example, one hammock, currently used by black-crowned and yellow-crowned night herons, is threatened by erosion near Rhodes Point. Erosion has been slowed by placing dredged material and geotextile tubes along the shoreline adjacent to this shrub community. However, the shoreline is still eroding, especially at the north end of the geotextile tubes (Mitchell and Gill [a] 1996).

The Maryland Department of Natural Resources (MDDNR) Program Open Space, evaluated the privately owned hammocks on Smith Island in 1990 (McKnight 1990). MDDNR recognized that these islands represent important rookery habitat, varying in quality according to size, vegetation, and proximity to human disturbance. The state also noted that a significant percentage of homes on Smith had recently been purchased as recreational/ vacation homes by off-islanders, and that several of the privately owned forested hammocks were for sale. Program Open Space concluded that development poses a potential threat for these habitats. Any disturbance to or alteration of the vegetation on these hammocks, such as construction of hunting facilities, could reduce their value as rookery habitats. As an example, the release of goats on the Pt. Comfort hammock on Smith, during 1993-1994, created a disturbance that reduced the (formerly) numerous nesting pairs of colonial waterbirds on that ridge by 93% in 1995 (Brinker et al. 1996).

Some of the rookery sites are associated with dredged material disposal sites. Several of these sites also contain the invasive plant *Phragmites australis*, likely because the plant readily colonizes bare, brackish or nutrient-poor substrates, such as dredged material. *Phragmites* sp. is a highly competitive plant that provides lower quality habitat than the heterogenous plant communities normally populating hammocks (Marks et al 1994). *Phragmites* sp. creates dense stands, with little vertical diversity - mammalian and avian population densities in *Phragmites* are generally low (Jones and Lehman 1987). *Phragmites* sp. may spread and outcompete woody species on the islands, rendering them less suitable for bird use. Or *Phragmites* sp. may spread to new islands, especially if the woody vegetation on these islands undergoes a disturbance, such as drought or fire.

In addition, there are red fox (*Vulpes vulpes*) populations on the island. While fox generally do not pose a threat to wading birds nesting high in trees,[5] they may currently limit the ability of these birds to breed in shrub communities on the hammocks.

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[5] G.Therres, Personal Communication, 1996, Maryland Department of Natural Resources, Division of Forestry, Wildlife and Heritage, Annapolis, MD.

Restoration/Protection Opportunities

Because the threat of development for many of the marsh islands haboring colonial waterbirds is real, USFWS recommends acquisition of the privately owned parcels, where possible, and transfer to a wildlife management or conservation organization, such as USFWS, MD-DNR, the Nature Conservancy, or the Chesapeake Bay Foundation (see Table A-3). Alternatively, USFWS recommends acquisition of conservation easements on these lands, with specific preservation/management agreements.

Eradication of *Phragmites* from the vegetative community at many of these marsh islands would enhance these habitats for colonial waterbirds. Sites should be spot-treated with an herbicide approved for use in aquatic systems, late in the growing season (which would also minimize disturbance to breeding birds). These areas could then be planted with native shrub and tree species, to provide additional rookery habitat. The dredge material disposal site at Easter Point, currently infested with *Phragmites* sp., holds great potential for conversion to important wading bird habitat. Eradication of *Phragmites* sp. and establishment of a coastal woody plant community on this site would create up to 20 acres of potential colonial waterbird habitat.

Erosion control presents another protection opportunity, especially for the rookery at Rhodes Point Gut. This particular island habitat is small, degraded by *Phragmites*, and populated with herring gulls, but it serves as breeding area for black-crowned night heron and yellow-crowned night heron. Further protection by beneficial placement of dredged material, eradication of *Phragmites* sp., and plantings of native tree and shrub species, would discourage gulls and enhance this area as colonial waterbird breeding habitat.

Finally, dredged material could be used to create new, isolated island habitats. Establishment of coastal woody plant communities on these islands, and diligent control of *Phragmites* sp. during the initial phases of vegetative development would be key to creating viable wading bird breeding habitats from dredged material. Such newly-created islands should be placed far from other marsh areas or uplands on Smith Island, to achieve isolation from mammal predators. These wooded communities may also serve as nesting sites for waterfowl such as American black duck and gadwall, especially if a vine groundcover develops.

TABLE A-3. Species composition of colonial waterbird colonies on Smith Island complex, 1995, with USFWS restoration/protection comments (species information from Brinker et al. 1996). Colonies listed below in bold type are located within the refuge.

Site Number	Site Name	Breeding Pairs in 1995	Restoration/Protection Notes
Som002	**Cherry Island**	GTBH, GREG, SNEG, CAEG, LBHE, TRHE, BCNH, YCNH, GLIB	Protected as part of Martin NWR, not threatened by erosion, 8 species, 297 pairs
Som013	Rhodes Point South	GREG, SNEG, CAEG, LBHE, TRHE, BCNH, YCNH, GLIB	Privately owned, 8 species, 539 pairs, 2 state-rare species, close to existing beneficial use/erosion control project
Som015	Hog Neck	GTBH, GREG, SNEG, LBHE, TRHE, BCNH, YCNH, GLIB	Privately owned, 8 species, 111 pairs, 2 state-rare species
Som017	Point Comfort	GREG, SNEG, CAEG, LBHE, TRHE, BCNH, YCNH, GLIB	Privately owned, 8 species, 299 pairs, 2 state-rare species
Som018	Ewell	GTBH, GREG, LBHE, TRHE, BCNH, YCNH, GLIB	Privately owned, 7 species, 121 pairs, 2 state-rare species
Som019	Rhodes Pt. Road	GREG, YCNH, GLIB	Privately owned, eroding, 3 species, 11 pairs, 1 state-rare species
Som020	Pines Hammock	GREG, SNEG, CAEG, LBHE, TRHE, BCNH, YCNH, GLIB	Privately owned, 8 species, 139 pairs, 2 state-rare species
Som021	Ireland Hammock	GTBH, GREG, SNEG, LBHE, TRHE, BCNH, YCNH, GLIB	Privately owned, 8 species, 69 pairs, 2 state-rare species
Som025	**Wellridge Creek**	GTBH, GREG, SNEG, CAEG, LBHE, TRHE, BCNH, YCNH, GLIB	Protected as part of Martin NWR, potential erosion threat, 9 species, 124 pairs, 2 state-rare species
Som027	Rhodes Pt. Gut	BCNH, YCNH, GBBG, HERG	Privately owned, 4 species, 4 pairs not including gulls, herring and great black-backed gulls present

Som028	Jean's Gut	SNEG, CAEG, LBHE, TRHE, BCNH, YCNH, GLIB, HERG	Privately owned, 8 species present, 109 pairs not including gulls, 2 state-rare species, herring gulls present
Som030	**Sawney Cove**	GBBG, HERG	Protected as part of Martin NWR, only herring gulls and great black-backed gulls present
Som038	Levering Creek	GBBG, HERG	Privately owned, only herring gulls and great black-backed gulls present
Som039	South Ewell	HERG	Privately owned, only herring gulls present
Som041	**Lookout Tower**	GREG, SNEG, CAEG, LBHE, TRHE, YCNH, GLIB	Protected as part of Martin NWR, not threatened by erosion, 7 species, 688 pairs, 2 state-rare species
Som044	**Terrapin Sand Pt**	GBBG, HERG	Protected as part of Martin NWR, potential erosion threat, only herring gulls and great black-backed gulls present
Som047	North Great Pond	HERG	Privately owned, only herring gulls present
Som048	Drum Pt Island	GBBG, HERG	Only herring and great black-backed gulls present

Key to Species Abbreviations

BCNH - black-crowned night heron
YCNH - yellow-crowned night heron
TRHE - tri-colored heron
GTBH - great-blue heron
CAEG - cattle egret
SNEG - snowy egret
GBBG - great black-backed gull
GLIB - glossy ibis
GREG - great egret
HERG - herring gull
LBHE - little blue heron

Terns, Skimmers, Pelicans and Gulls

Population/Habitats/Threats

Colonial waterbird species, other than wading birds, are generally characterized as terns, skimmers, gulls and pelicans (see Table A-4). In studies along the mid-Atlantic barrier islands of Virginia, Watts (1994) described three major categories of nesting habitat for these species: 1) sandy or shell substrate, 2) dune grasslands and 3) isolated ridges surrounded by marsh. Although Smith Island is not a barrier-lagoon system, it contains several habitats similar to those in Virginia, including sandy beaches, small dune grasslands, and isolated marsh ridges.

Generally, the largest and most stable, productive colonies of terns and skimmers occur on upper foredune areas of isolated sandy beaches, usually on small islands that are not likely to be overwashed during spring or small storm tides (Watts 1994). In addition, piles of shell and sand on ridges isolated by tidal marsh are also significant nesting areas for gull-billed tern, black skimmer, common tern (*Sterna hirudo*) and least tern (*Sterna albifrons*). Forster's tern also breed on isolated ridges, and on wrack deposits in tidal marsh (Watts 1994). Since 1985, populations of common tern and Forster's tern in Maryland have declined significantly (Brinker et al. 1996)and the Maryland population of least tern and black skimmer, while currently stable, are listed as threatened (McKnight, pers comm).

Brown pelicans traditionally bred in the coastal zone of the southeastern United States, including the Atlantic Coast from North Carolina to Florida, and the Gulf Coast from Florida to Texas (Hamel 1992). However, recent improvements in coastal water quality and protection of important nesting areas have contributed to an apparent northward expansion of the breeding range into the mid-Atlantic coast and Chesapeake Bay. The Atlantic coast population of brown pelican has recovered and was removed from the Federal list of endangered species in 1985. Although the eleven-year trend for brown pelicans in Maryland is stable, their numbers declined in 1994-1995 (Brinker et al. 1996). Preferred nesting habitat are dune grasslands in coastal areas, especially on small islands (Watts 1994).

Herring gulls and great black-backed gulls primarily nest in dune grassland and elevated, vegetated marsh ridge habitats (Watts 1994). Herring gulls were the second most abundant breeding waterbird in 1995, with 2,410 pairs counted in Maryland, and their population trend has been stable since 1985 (Brinker et al. 1996). In Maryland, great black-backed gulls have increased in population since 1977, and they generally associate with nesting herring gulls (Erwin 1979). These two gull species are significant predators upon terns and skimmers, and are not a priority species for restoration efforts.

Species in the tern, skimmer, pelican and gull groups, which have been recorded as nesting in Maryland, are listed on Table A-4. The 1995 comprehensive census of colonial waterbirds nesting in Maryland did not record the presence of breeding pairs of any of these species, except herring and great black-backed gulls at Smith Island. However, the Maryland Department of Natural Resources, Heritage and Biodiversity Conservation Resource Management Team reported the historical presence of two of these species at Smith Island: least tern (threatened), and black skimmer (threatened).

The 1995 census did record breeding activity for two tern species (common and Forster's) and black skimmer along the western shore of South Marsh Island Wildlife Management Area, less than 8 miles north of the Smith Island. In 1996, USFWS personnel observed an active brown pelican colony (previously observed on Shank's Island) at Cheeseman Island, on the south end of the Smith Island in Virginia (Mitchell and Gill 1995).

Degradation and loss of habitat has likely contributed to declines in tern and skimmer populations in Maryland. Erosion has significantly impacted the isolated offshore habitats used extensively by these species; over 10,500 acres of these island habitats have been lost in the middle eastern portion of the Chesapeake Bay in the last 100 to 150 years (Galenter 1990). In addition, waterfront development and shoreline stabilization have been extensive in the Chesapeake Bay and Maryland coastal bay regions, including privately-owned island waterfront beaches. As evidence of limited available breeding habitat in the Chesapeake Bay region, 10 of the 15 active least tern colonies (or 63%) in Maryland in 1995 were on gravel rooftops, instead of shoreline habitat.

Predators of ground-nesting waterbirds include Raccoon (*Procyon lotor*), red fox, gulls and crows (*Corvus ossifragus*) (Amos and Amos 1989). The presence of predators on large Chesapeake Bay Islands, such as Smith Island, poses a threat to any potential tern and skimmer colony. In Virginia, the Nature Conservancy Virginia Coast Reserve has documented the disappearance of waterbird colonies from Smith, Metompkin, and Parramore Islands as raccoon and fox populations increased (Stolzenburg 1995). Red fox, herring, and great black-backed gull populations exist on Smith Island.

Restoration/Protection Opportunities

Restoration initiatives for breeding habitats for terns and skimmers are limited on Smith Island. These species require sandy foredunes and unvegetated ridges within marshes, well isolated from mammalian predators, to establish successful breeding colonies. The Patuxent Wildife Research Center is currently conducting a pilot study of red fox populations on Smith Island. Preliminary information indicates that red fox are able to use all of Smith Island and readily swim across major tidal creeks to reach isolated ridges and sandy beaches.[6]

Any beneficial use projects that include breeding terns and skimmers should focus on creating sandy foredunes and elevated marsh ridges at isolated points around the island complex, i.e. the small islands between Smith and Tangier Islands. These sandbars and/or marsh ridges should be created at elevations 6-8m above the highest tides, and should be protected from erosion with geotextile tubes or other erosion barriers to assure long-term availablity of breeding habitat. However, if sites succeed to native dune grass communities, they may become unsuitable for tern and skimmer species, and instead become colonized by gull, pelican, or solitary shorebird species (Soots and Parnell 1975). For brown pelicans it will be virtually impossible to use dredged material to create breeding habitat (dune areas sparsely vegetated with beach grasses) without creating potential breeding habitat for herring gulls.

[6] **D.Jorde, PhD., Personal Communication, 1996,Patuxent Wildlife Research Center, USGS, Biological Resources Division, Laurel, MD.**

Table A-4 Colonial waterbird species, other then wading birds, which have been recorded as nesting in Maryland (Robbins 1996)

Species common name	Scientific name	Status
brown pelican	*Pelecanus occidentalis*	
double-crested cormorant	Phalacrocorax auritus	
great black-backed gull	Larus marinus	
herring gull	Larus argentatus	
laughing gull	Larus atricilla	
royal tern	Sterna maxima	
sandwich tern	Sterna sandvicensis	
common tern	Sterna hirundo	
roseate tern	Sterna dougalii	
Forster's tern	Sterna forsteri	
least tern	Sterna antillarum	threatened
gull-billed tern	Sterna nilotica	
black skimmer	Rynchops niger	threatened

Shorebirds

Populations/Habitats/Threats

There are few shorebirds that have historically bred at Smith Island. However, willet (*Catoptrophorus semipalmatus*) nests were located on Smith in 1996.[7] American oystercatcher (*Haematopus palliatus*), a state-listed rare shorebird, have also been sited on the island (Armistead, 1974). Willets generally nest just above the beach foredune, in dune grass or even low shrub communities (Bent 1962, Hayman et al. 1986), while oystercatchers nest in habitats similar to least tern breeding areas, i.e. higher parts of dry, flat, sandy beaches (Bent 1962).

While shorebird breeding activitiy at Smith is low, migrating shorebirds make extensive use of the mudflats and sandy intertidal areas on the island complex. Numerous species of shorebirds stopover and feed in the Smith Island during spring and fall migration such as plovers, various sandpipers; dowitchers; yellowlegs, etc. (see Table A-5).

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[7] D.Jorde, PhD. Personal Communication, 1996, Patuxent Wildlife Research Center, USGS, Biological Resources Division, Laurel, MD.

Table A-5 Shorebirds recorded at Martin National Wildlife Refuge.[8]

Common Name	Scientific Name
American oystercatcher	
willet	
semipalmated sandpiper	
spotted sandpiper	
least sandpiper	
western sandpiper	
purple sandpiper	
pectoral sandpiper	
black-bellied plover	
semipalmated plover	
killdeer	
dunlin	
red knot	
lesser yellowlegs	
greater yellowlegs	
snipe	
sanderling	

Shorebirds rely on sandy and muddy shorelines as forage and rest sites. These birds feed on small mollusks, worms, and crustaceans, foraging in mudflats, tidal pools, and sandy intertidal zones. Tidal flats on Smith Island, such as those found along the eastern shoreline at Twitch Cove, Wellridge Creek, and the southeastern shore of Big Thoroughfare, provide such forage areas.

Erosional and human-caused loss of island and mainland shoreline habitat in the Chesapeake Bay, as described in the sections on colonial waterbirds, has decreased forage, resting, and (to a limited exent) breeding habitats for shorebirds.

Restoration/Protection Opportunities

Because of its isolation from the mainland Smith Island presents an opportunity to create temporary avian foraging and resting sites, as well as more permanent foraging and breeding

8 E.Johnson, Personal Communication, 1996, Blackwater National Wildlife Refuge, Cambridge, MD.

areas. Dredged material, sandy or more fine-grained, could be placed along shorelines protected from waves and currents. If the final elevation of the dredged material placement site is intertidal, it could serve as a forage site. However, such projects will likely create only *temporary* feeding/resting habitat for shorebirds and other wading birds. These areas will not require maintenance, nor stability structures.

Dredged material could also be incorporated into long-term habitat types, with erosion control benefits. Material, especially sandy material, could be placed behind properly sized stabilizing structures (such as geotextile tubes or low-elevation rip-rap) to create permanent forage areas along eroding shorelines. Such projects have already been carried out within the Chesapeake Bay, such as at Eastern Neck NWR (Gill et al. 1995). Tidal pools and intertidal flats could be shaped from dredged material, potentially creating forage habitat for dabbling ducks, geese, shorebirds and wading birds. Higher dune areas, created by mounding dredged material behind the intertidal placement area, could serve as breeding habitats for various coastal birds, depending upon the material type and the succeeding vegetation.

Restoration initiatives for shorebird breeding habitats, such as willet and American oystercatcher, are limited on Smith Island. Use of dredge material to create back-dune grassland habitats suitable for willets also carries the potential to create areas attractive to breeding herring gulls. Such creation sites should be planted with coastal shrub species to discourage gull use. Beneficial use projects focused on restoring foredune habitats for terns/skimmers, as descibed above, may also benefit the American Oystercatcher. These restoration sites should be well isolated from mammalian predators.

Waterfowl

North American Trends

Certain waterfowl populations have declined at Smith, reflecting waterfowl trends throughout North America. Between 1958 and 1963, North American pintail breeding population estimates dropped from about 10 million to about 3 million. After a rebound in the early 1970's, populations declined again to present levels of about 2 million pintails (Caithamer et al. 1995). Similarly, mallard populations in North America generally declined, dropping from an estimated breeding population of about 10 million in 1971 to about 4.5 million from the late 1980's through to 1993 (Caithamer et al. 1995). North American widgeon breeding populations declined from the early 1980's (about 3.5 million) to the mid-1980's (about 1.75 million). The USFWS attributes these decreases largely to prairie nesting habitat loss and degradation (Caithamer et al. 1995). More recently (1995-1996), estimated numbers of these and other dabbling ducks have increased, attributed, in part, to favorable climatic conditions on breeding grounds.

Mid-Atlantic Trends

Mid-winter counts of diving ducks have also decreased considerably on the Chesapeake Bay. Diver numbers in mid-winter in the Chesapeake Bay between 1987-1996 (165,323) were much lower than the 1956-1965 average (250,459), as well as the 1956 and 1996 average

(192,938). These trends were generally reflected at Smith Island. Mid-winter counts of diving ducks at Smith between 1987-1996 (734) were lower than the 1956-1996 average (1,395).

During the 1950's, the Chesapeake Bay harbored over 250,000 wintering canvasbacks. These populations declined to about 50,000 in the late 1980's, and have slightly rebounded to about 60,000 currently (Haramis 1991; Forsell 1996). While several factors have contributed to the decline of North American populations of canvasback (loss of prairie nesting habitat, degradation of migratory habitat, hunting pressure), the USFWS considers one of the most important factors in the Chesapeake Bay to be the drastic decline in Submerged Aquatic Vegetation (SAV) during the 1970's (Haramis 1991). Canvasbacks will consume animal foods, such as Baltic clam and mud crab; however, preferred food items are wild celery, eelgrass, sago pondweed, redhead grass, and widgeon grass. As these plant species have declined in the Chesapeake Bay, so have numbers of canvasback.

Redhead were also historically abundant diving ducks in the Chesapeake Bay region. During the late 1950's and early 1960's, midwinter counts of redhead in the Bay were on the order of 50,000 (Forsell 1996). As with the canvasback, habitat destruction and hunting pressure have contributed to redhead declines. In addition, the redhead is also an important consumer of SAV. During fall and spring migration, redhead were historically found in fresh and brackish SAV areas in the upper and middle Bay. Cold winter periods, with heavy freezing, generally moved the birds to the eelgrass and widgeon grass beds in the lower Bay (Haramis 1991). However, as SAV declined in the Chesapeake Bay, redheads did not adapt to animal foods, but essentially abandoned the region. Populations shifted south, to North Carolina, and most likely the Florida Gulf coast (Haramis 1991). Chesapeake Bay mid-winter populations have drastically declined since the 1960's, to a low, relatively stable average of about 1,921 birds (1987-1996).

Other waterfowl populations have shown declines. Mid-winter Canada goose counts in the Chesapeake Bay have declined since the late 1980's. Current mid-winter counts stand at approximately 300,000 birds, while numbers in the 1980's were generally above 500,000 geese. The Canada goose population in the Atlantic flyway is currently in decline, prompting the closure of the hunting season on this species in 1996. Recent (1987-1996) average midwinter populations of Canada goose at Smith Island (1,612) are lower than historic (1956-1965) average midwinter populations (2,902) (Forsell 1996).

Smith Island Trends

The Atlantic mid-winter waterfowl survey is flown along standardized flight-paths along the major rivers and water bodies in the Atlantic flyway, including the Chesapeake Bay. The survey is conducted during the first 2 weeks of January and provides a comparative index of mid-winter waterfowl populations along the flyway. Numbers of species counted at Smith Island during the mid-winter waterfowl surveys, between 1956 and 1996 and the mid-winter counts for each species across the entire Chesapeake Bay are listed in Tables at the end of this Appendix. Also shown in the Tables is the average count for each species, at Smith Island, for the intervals 1956-1965, 1987-1996, and 1956-1996. In addition, each of these average counts for Smith Island is represented as a percentage of average Chesapeake Bay counts for these time intervals.

The average number of dabbling ducks counted in mid-winter in the Chesapeake Bay between 1987-1996 (91,743) was lower than the 1956-1965 average (177,039), and lower than the overall average between 1956 and 1996 (119,789). These trends were reflected at Smith Island. Mid-winter Smith Island counts between 1987-1996 (1,300) were much lower than the 1956-1965 average (5,563), and the 1956-1996 average (2,715).

Recently, mid-winter counts of dabbling ducks on the Bay (1991-1996) have shown slight increases since the 1980's. USFWS reports that the increase in dabbling duck counts in recent years is due, in part, to good reproductive success on prairie breeding grounds. However, the average number of dabbling ducks counted during mid-winter at Smith Island did not increase during the 1990's.

Smith Island harbors an important proportion of the midwinter populations of dabbling ducks on the Chesapeake Bay - 2.27% of the counts for the entire Chesapeake Bay between 1956-1996. Over this time period, the island complex contained over 1% of the Chesapeake Bay mid-winter counts for the following species: black duck, gadwall, widgeon, and pintail. In addition, Smith contained over 1% of the Chesapeake Bay mid-winter counts for five other species of waterfowl: readhead, bufflehead, scoter, oldsquaw, brant, and tundra swan. Considering that Smith Island contains (.0001 %?) of the shoreline of the entire Chesapeake Bay, the island concentrates a major portion of the mid-winter waterfowl population of the bay in a small area.

Compared to 1956-1965, the 1987-1996 mid-winter counts on Smith Island have decreased for mallard, black duck, widgeon, pintail, redhead, and canvasback. In addition, the percentage of the Chesapeake Bay mid-winter counts on Smith dropped: pintail (23.57% down to 1.76%) and mallard (0.52% down to 0.17%).

Except for mallard, several species have declined throughout the Chesapeake Bay during the 1956-1996 interval. Of these six species, only black duck and mallard breed in significant numbers on the Chesapeake Bay. Breeding black duck populations in the Atlantic flyway, including Maryland, have suffered precipitous declines since the 1950's, generally due to over harvest, loss of breeding and wintering habitat, pollution, and hybridization and competition with the mallard (USFWS 1986, Krementz 1991). Although they have recently stabilized, populations of black duck continue to be low, about 10% of populations in the 1950's (Krementz 1991).

Smith Island Foraging and Migrating Habitats

Smith Island contains extensive shallow-water habitats, SAV beds, tidal mudflats, and miles of fringing low marsh. Each of these habitats provides important wintering forage for a variety of waterfowl. The large eelgrass and widgeongrass beds in the Big Thoroughfare, Terrapin Sand Cove, Shanks Creek, and Back Cove are important to migrating and wintering waterfowl as feeding and resting areas. Eelgrass is an important food source for American black duck, widgeon, Canada goose, redhead, and brant. The plant provides nutrition through seeds, leaves, and root-stalks (Hurley 1992), and associated invertebrate foods. Widgeongrass, which generally grows in shallower habitats than eelgrass, is consumed by a variety of ducks that frequent Smith Island: black duck, gadwall, widgeon, mallard, green-wing and blue-wing teal, and pintail, and Canada goose and tundra swan (Martin et al. 1951; Bellrose 1976; Hurley 1992).

Low marsh habitats on Smith Island (extensive *Spartina alterniflora* marshes fringing tidal creeks and the associated mudflats) also provide important waterfowl forage areas for animal foods. American black duck, in particular, can subsist to a large extent on animal foods found in the low saltmarsh such as snails, mussels, small crustaceans, and aquatic insects (Martin et al. 1951; Bellrose 1976). Mudflat habitats and shallow marsh habitats are also heavily used by green-winged and blue-winged teal. These ducks feed upon the seeds of moist soil plants deposited in the intertidal zone, and associated invertebrate species (Bellrose 1976). *Spartina alterniflora* rootstocks are a significant part of the diet of wintering snow- and Canada- geese (Martin et al. 1951; Bellrose 1976).

Smith Island Breeding Habitats

Smith Island is an important breeding area for American black duck, mallard, and to a lesser extent, gadwall, on the Chesapeake Bay. Black duck nest in a variety of habitats on the Chesapeake Bay, including wooded areas, marshes, and old duck blinds (Stotts and Davis 1960). Mallards and Gadwall prefer to nest on small upland sites, such as the hammocks at Smith, rather than directly over marshes (Bellrose 1976).

Restoration/Protection Opportunities

Restoration

Martin National Wildlife Refuge and undeveloped marshes of Smith Island provide important habitats for wintering and migrating waterfowl, including dabbling ducks and geese. Creating tidal wetlands and/or mudflats, through intertidal placement of dredged materials, may benefit these species. Also, creating temporary avian foraging and resting sites (see the shorebird habitat section of this report) could also serve as forage habitat for waterfowl such as black ducks, mallard, gadwall, and teal. Dredged material placed along shorelines, protected from major wave and current influence, could serve as temporary feeding/resting habitat for waterfowl.

In addition, dredged material could also be incorporated into long-term waterfowl habitats. Material placed behind properly sized stabilizing structures could be planted with high-marsh and low-marsh wetland vegetation, to create more permanent saltmarsh forage and potential breeding habitats for waterfowl species. These marsh creation projects should incorporate raised ridges of material, and interior tidal pools, into the overall marsh design, to maximize the diversity of vegetative communities. These marsh creation projects could benefit a variety of waterbirds, including waterfowl and wading birds, while protecting eroding shorelines.

Restoration activities on existing large dredge-material disposal sites on Smith Island, such as the site at Easter Point, could benefit waterfowl. Nontidal or brackish pools could be created in the interior areas of such dredge sites, where material is generally fine-textured and poorly drained. Such pools could be planted with, or be allowed to naturally populate with, submerged aquatic vegetation native to the region, such as widgeongrass (*Ruppia maritima*), muskgrass (*Chara* sp.), and pondweeds (*Sago* sp.). These species would provide feeding areas for dabbling ducks. In addition, eliminating *Phragmites* sp. using herbicide, and planting with coastal shrubs and grasses, would greatly enhance these sites as potential breeding areas for waterfowl, or shrub-nesting colonial waterbirds. For example, habitat restoration on a diked-dredge disposal area is currently underway at Swash Bay, Virginia, through a cooperative arrangement between the Norfolk Corps of Engineers, The Nature Conservancy Virginia Coast Reserve, and the U.S. Fish and Wildlife Service (Mitchell and Gill [b]1996).

Dabbling ducks that breed at Smith Island could benefit from newly created isolated islands from beneficial placement of dredged material. New marsh and upland habitats may provide additional forage habitats for a variety of waterfowl, and nesting habitat for mallard, black duck and gadwall. These creation activities should focus on creating islands in areas that do not currently contain important benthic habitats and are isolated from large uplands areas inhabitated by mammalian predators. Final elevation of these islands should be 6-8 m above high tides, which can cause nest failure in tidal marshes. The islands should be vegetated with tall, dense, herbaceous vegetation, such as salt meadow hay and switchgrass (*Panicum virgatum*), and coastal shrubs. For example, similar island creation projects are underway at Poplar Island, in Chesapeake Bay, and Chincoteague Inlet, in the Coastal Lagoon System in Virginia.

In past decades, dieout of eelgrass along the Atlantic Coast has been blamed for decreases in Atlantic brant populations (Bellrose 1976; Martin et. al. 1951). Other waterfowl feed on eelgrass, including widgeon, black duck, scaup and scoters. Re-establishment of eelgrass beds, or creation of new beds would benefit waterfowl, especially Atlantic brant. Researchers believe that new beds of eelgrass establish on sandy substrates, and gradually accumulate finer sediment particles, by slowing currents (Stevenson and Staver 1996, Taylor 1996). Establishment of eelgrass beds in sandy substrates is currently under investigation, and bears further research. The Nature Conservancy reports that attempts within the Virginia Coastal Reserve to establish eelgrass have not been successful.[9] The Virginia Institute of Marine Science has undertaken several SAV establishment projects in Virginia in the last 15 years. Bob Orth of VIMS reports that these experiments have had low survivorship and potential propagule problems. Research is ongoing, focusing mechanisms of revegetation of existing SAV beds.[10]

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[9] B.Truitt, Personal Communication, 1996, The Nature Conservancy, Virginia Coast Reserve, P.O. Box 158, Nassawaddox, VA.

[10] R.Orth, Personall Communication, 1996, during the EPA Chesapeake Bay Program, Submerged Aquatic Vegetation Workgroup Meeting, Dec. 6, 1996, Annapolis, MD.

Protection

SAV beds provide critical feeding and resting areas for waterfowl. SAV beds at Smith Island that are threatened by erosion (e.g. in Terrapin Sand Cove and Twitch Cove) could be protected through beneficial use of dredged material. Material could be used to create erosion barriers, such as geotextile tubes, or to reinforce eroding spits of land that currently protect important SAV beds, e.g. the eroding islands at Terrapin Sand Point. In addition, dredged material could be used to close recently blown-out guts on the west side of Smith Island. These blow-outs may have increased water energy within the interior bays of Smith (e.g. the Big Thoroughfare, and Shank's Creek), and may contribute to loss of SAV at Smith.

U.S. Fish and Wildife Service personnel[11] and biologists from the Patuxent Wildlife Research Center[12] have observed black duck nests on the upland hammocks on Smith Island. As noted above, these hammocks are generally vegetated with coastal shrubs, vines, and dense grasses, nesting habitats utilized by black duck and gadwall on the Chesapeake Bay (Stotts and Davis 1960). These hammocks are limited on Smith Island, and potentially important to a variety of species. As noted in the colonial waterbird restoration-protection section, these sites should be acquired and/or protected by permanent conservation easements/agreements.

MAMMALS

The most prevalent mammalian species on Smith Island are muskrats (*Ondatra zibethica*) and small rodents such as the meadow vole (*Microtus pennsylvanicus*). River otter (*Lutra canadensis*), mink (*Mustela vison*), and red fox also occur. Restoration projects which protect and/or create wetland habitats will benefit aquatic furbearer species. Upland habitat restoration will benefit rodents and the red fox. As discussed in the report sections dealing with waterbirds, projects which promote fox habitat will negatively impact ground nesting birds. Given the population status of these two guilds of animals, waterbird breeding habitats should be prioritized.

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[11] M.Harrison, Personal Communication, 1996, Glenn L. Martin National Wildlife Refuge, Ewell, Smith Island, MD.

[12] G.M. Haramis and D. Jorde, Personal Communication, 1996, Patuxent Wildlife Research Center, USGS, Biological Resources Division, Laurel, MD.

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Smith Island SAV/seagrass environmental feasibility study

A report submitted to the

U.S. Army Corps of Engineers

Baltimore District

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Smith Island SAV/seagrass environmental feasibility study

Table of Contents

The decomposing leaves of seagrasses provide perhaps one of the most important sources of food in shallow coastal areas colonized by seagrasses (Boynton and Heck, 1982; Kemp et al., 1984). Epiphytes growing on seagrass leaves can be an even more important food source than the leaves themselves (van Montfrans et al., 1984). Not only the seagrass leaves and their epiphytes provide a good food source: the blue crab (Callinectes sapidus) and the herbivore fish Micropogonias undulatus (very abundant in Chesapeake Bay), can consume up to 65% of the seeds of Zostera marina. This has the potential to affect the plant population dynamics.

Fisheries Habitat

One of the major importances of seagrass beds is their association with a variety of organisms. The species richness and abundance within seagrass beds is higher than in unvegetated areas (Lubbers et al., 1990; Sogard and Able, 1991). This association between plants and animals has been attributed to the rich source of foods within the seagrass beds (Lubbers et al., 1990), the nursery environment provided by the vegetation (Orth and van Montfrans, 1987) and the refuge the three-dimensional habitat provides for a variety of organisms (Leber, 1985). As mentioned above, seagrass beds have very high primary production providing a wide range of food sources to associated organisms (Lubbers et al., 1990). Additionally, seagrass beds provide an area for settlement of larvae (see wave attenuation below) and, therefore, juveniles of a variety of species spend the beginning of their lives within seagrass beds (Orth and van Montfrans, 1987; Bell et al., 1988). There are exceptions to this rule. Olney and Boehlert (1988) suggested that pelagic eggs and early larvae may actually be predated upon at a higher rate within than outside seagrass beds. These organisms would benefit from seagrasses only at later developmental stages. The blue crab (Callinectes sapidus) takes advantage of seagrass beds specially during the phase of transition between the old hard exoskeleton and the new soft exoskeleton (Ryer et al., 1990).

Another argument to explain the higher diversity and abundance of organisms within versus outside seagrass beds is the refuge that the seagrass leaves provides from predators. Larger species can not swim through dense seagrass beds (Olney and Boehlert, 1988). However, it is not clear if seagrass density plays a major role in this refuge function. Some argue that density accounts for very little of the distribution of species associated to seagrasses (Worthington et al., 1992) while others argue that the density of the organisms in seagrass beds is directly related to the density of the vegetation (Ansari et al., 1991). Apparently, high seagrass density can be detrimental to blue crabs since a thick rhizome mat may reduce the ability of the crabs to hide and bury in the sediment (Wilson et al., 1987). A similar case was observed for the burrowing shrimp (Callianassa californiensis) whose population declined as an eelgrass bed expanded. This was attributed to a possible inhibition of burrowing due to the seagrass rhizomes in the sediment or, perhaps, more shrimp predators within the seagrass bed (Harrison, 1987). In another case, mussels (Mytilus edulis) associated with seagrass beds actually promoted the growth of eelgrass by increasing the amount of nutrients in the sediments via mussel feces (Reush et al., 1994). Therefore, the interactions between seagrasses and their associated fauna can be quite complex.

In the lower Chesapeake Bay, eelgrass and widgeon grass beds support 75 macrofauna species that exhibit densities of 12,000 to 70,000 individuals m^{-2} (Orth and van Montfrans, 1982). The production of invertebrates associated with these seagrass beds is estimated to be 55.9 metric tons. More than 107,000 blue crabs, one of the most important fisheries in the Chesapeake Bay, are estimated to be produced every year in 1 ha of seagrass bed in the lower bay (Fredette et al., 1990).

Nutrient uptake

Another major importance of seagrass beds is their capacity to uptake nutrients from the water column as well as the sediments (Short and Short, 1984; Romero et al., 1994). Although the effects of eutrophication are mostly felt in the water column (phytoplankton growth), the sediments can significantly contribute to eutrophication via nutrient release (Short, 1983; Erftemeijer and Middelburg, 1995). Therefore, it is important to not only consider the nutrient uptake capacity of the seagrass leaves but also that of the roots as both these plant components can contribute to a reduction in nutrients/eutrophication.

Seagrass roots nutrient uptake can account for as much as 66 to 98% of the total nutrient uptake in some of the larger seagrasses like Enhalus (Erftemeijer and Middelburg, 1995). In some of the smaller seagrasses, like Zostera marina, this uptake may still account for 82% of the total uptake (McRoy and Goering, 1974). In contrast, leaves tend to uptake less nutrients due to the higher availability of nitrogen and phosphorus in the sediments (Erftemeijer and Middelburg, 1995).

Several factors affect the nutrient uptake by seagrasses: leaf morphology, nutrient concentration in the water and sediment, and water flow (Short and Short, 1984). Seagrasses with large leaf area tend to accumulate more nutrients than seagrasses with smaller leaf area (Short and Short, 1984). As stated above, if nutrients are higher in the sediment than in the water column (usually the case), then seagrass roots will take up more nutrients than the leaves (Brix and Lyngby, 1985). The nutrient uptake by leaves increases with the concentrations of nutrients in the water column (Short and McRoy, 1984) but, at very high nutrient levels (25 μM ammonium), nitrogen toxicity can be experienced by seagrasses (van Katwijk et al., 1997). The supply of nutrients to the plants depends on water flow. If the flow is relatively slow, nutrients can become limiting in the water column increasing the concentration difference between water column and sediments even further (Short and Short, 1984).

This capacity of seagrasses to remove nutrients from the water column as well as the sediments accounts for a major sink of nutrients in coastal shallow waters. It was calculated that the tropical seagrass community in the Indian River Lagoon, FL in 1976 had the potential to remove 3,890 tons of nitrogen from that system (Short and Short, 1984). The removal varies seasonally with highest uptake rates in the summer when growth rates are fastest. In a temperate system colonized by Zostera marina (The Netherlands) it was estimated that the amount of nutrients fixed by the seagrasses during the growing season was equivalent to 178 tons of nitrogen and 29 tons of phosphorus (Pellikaan and Nienhuis, 1988). Therefore, if seagrasses are declining in a coastal ecosystem, the potential for eutrophication related problems, is enhanced.

Wave attenuation

In the natural environment, seagrass beds can be identified from a distance by searching for flat/calm surfaces amidst wavy waters. This is due to the strong capacity of

Bay, including the western shore of Smith Island. If sand bars or shoaling reduce the wave energy in these areas, seagrass populations can occur despite the apparent high wave energy impacting these areas. Therefore, underwater breakwaters may have the same positive effect on potential seagrass habitats.

Among the seagrass species that occur in the Smith Island area, Zostera marina seems to be more wave tolerant than Ruppia maritima (Orth and Moore, 1988). This difference in wave tolerance is attributed to deeper rhizomes in Zostera when compared to Ruppia, making them less erodable during storm events. The only other attempt to identify the maximum wave energy tolerated by eelgrass found that 2 m waves are the maximum limit (Dan et al., 1998). In Chesapeake Bay, the waves are usually smaller than that.

In summary, seagrass distribution is limited by high wave energy but, within the wave energy regimes that they can tolerate, seagrasses are very efficient in reducing wave energy. By attenuating wave energy, seagrasses have the potential to reduce erosion of the sediment they colonize as well as that of the adjacent coastline. Therefore, seagrass beds have the potential to save money spent on beach renourishment and shoreline stabilization.

Reduction in current velocity

Seagrass beds reduce current velocity by extracting momentum from the moving water (Madsen and Warnke, 1983). The magnitude of this process depends on the density of the seagrass bed (Gambi et al., 1990; Carter et al., 1991; van Keulen, 1997), the hydrodynamic conditions of the area (stronger reduction in flow in tide- dominated versus wave-dominated areas: Koch and Gust, 1999) as well as the depth of the water column above the plants (Fonseca et al., 1982). The highest reduction in current velocity occurs in dense, shallow beds exposed to tide-dominated conditions (unidirectional flow). In Tangier Sound, the tidal amplitudes are among the highest in Chesapeake Bay. Therefore, tidal currents are expected to be relatively strong. Seagrasses could be an important mechanism to reduce sediment erosion via sediment stabilization is such areas as currents in seagrass beds can be 2 to 10 times slower than in adjacent unvegetated areas (Ackerman, 1983; Madsen and Warncke, 1983; Carter et al. 1988; Gambi et al., 1990; Rybicki et al., 1997).

The range of current velocities tolerated by seagrasses lies between 3 and 180 cm s^{-1}. Eelgrass seems to need at least 3 cm s^{-1} to maximize growth (Koehl and Worcester , 1991). A minimum current requirement for widgeon grass is unknown but is probably lower than that that for eelgrass since this species is less wave tolerant and is also commonly found in drainage ditches and relatively stagnant ponds. The maximum current velocity at which Zostera marina was found is 180 cm s^{-1} (Phillips, 1974). Once again, the maximum current velocity tolerated by Ruppia maritima is unknown but it is expected to be lower than that of Zostera due to the shallow rhizomes which can be easily eroded.

The capacity of seagrasses to reduce current velocities has direct positive implications in: 1) the stabilization of the sediments colonized by seagrasses when compared to adjacent unvegetated areas (Fonseca and Fisher, 1986; references in the review by Fonseca, 1996); 2) the longer residence time of water within the vegetation leading to more nutrient uptake (Bulthuis et al., 1984) and 3) the increased settlement of spores of algae and larvae of a variety of organisms resulting in higher species diversity best of my knowledge, no economical estimate of the advantage of having seagrasses trap sediments versus replenishing beaches is available.

Summary

Seagrass beds are of extreme ecological and economical importance due to their capacity:

1) to provide habitat and food for a variety of commercially important species above and below the water;
2) to remove nutrients from the water column minimizing the impact of eutrophication;
3) to attenuate wave energy reducing coastal erosion and sediment resuspension;
4) to decrease current velocity also reducing coastal erosion and sediment resuspension.

As a result, in coastal areas where seagrasses colonize shallow waters, more seafood and waterfowl are available, waters are cleaner and more attractive to tourism, and less money needs to be invested in coastal structures for shoreline stabilization or beach renourishment.

The decline of seagrasses with special emphasis on the waters adjacent to Smith Island and in Tangier Sound

Introduction

Seagrass populations have shown a general decline worldwide since the 1960's. The early causes for decline were due to dredging of areas nearby seagrass beds and filling on top of the shallow seagrass beds in order to reclaim land. The dredging activities increase the amount of suspended particles in the water column and, consequently, reduced the light available to the plants. Additionally, sedimentation rates on seagrass leaves increases after dredging, many times burying the plants. Both the reduction in light available and the increased sedimentation can lead to the death of the seagrasses.

Boat scars generated by prop dredging sediments colonized by seagrasses also make the seagrass beds more vulnerable to erosion (Walker et al., 1989). The recovery of boat-scar impacted Thalassia testudinum beds has been estimated to be as high as 7.6 years (Dawes et al., 1997). The recent practice of hydraulically dredging seagrass beds for clams also generates scars equivalent to the boat scars but wider and deeper (Orth, personal communication). The time for recovery of these scars and their impact on the seagrass community is not known at this time. It is believed to be in the order of years possibly making the seagrass beds vulnerable to erosion. The MD Department of Natural Resources passed a mandate in 1998 no longer allowing clam dredging in most seagrass beds in Chesapeake Bay but the plumes of high suspended matter created by this practice still have the potential to negatively impact the seagrass beds in Chesapeake Bay.

Another cause for the decline of seagrasses in specific areas is an increase in the population of cownose rays (Orth, 1976). These organisms feed on the molluscs in the seagrass beds and, in the process, uproot entire plants creating circular unvegetated areas similar to the boat and claming scars mentioned above.

Perhaps the most wide spread and most detrimental impact on seagrasses comes from eutrophication (increase of nutrients in the water column). When nutrients from land (sewer treatment plants, farm/city runoff) are discharged into coastal waters, they fuel the growth of planktonic algae (unicellular algae in the water column) which, in turn, reduce the light that reaches the bottom of these coastal systems which are also seagrass habitats. The enhanced nutrient levels also lead to enhanced algal growth on the seagrass leaves (epiphytes) which cause additional light attenuation. As a result, the amount of light that reaches the plants is significantly reduced, possibly leading to their death. Eutrophication is believed to have cased the decline of seagrasses worldwide as well as in the Chesapeake Bay (Dennison et al., 1993).

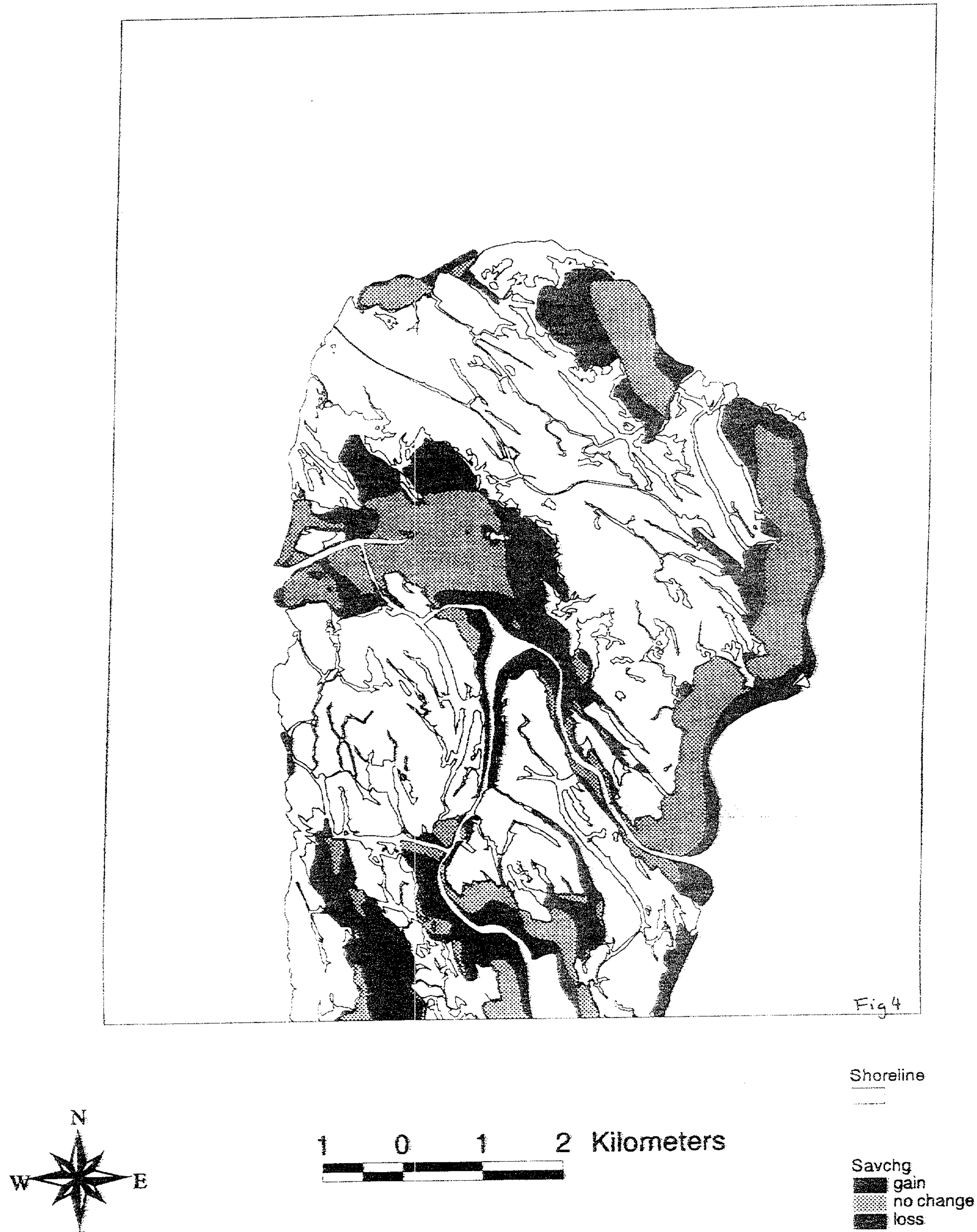
The decline and change of seagrasses in Chesapeake Bay

The decline of seagrasses in the Chesapeake Bay started in the 1930's and affected only one species, Zostera marina. This declined occurred worldwide and is believed to have been caused by the infection of the plants by a slime mold, Labyrinthula. The eelgrass populations in the bay recovered from this disease but, since the 1960's, there has been a continuous decline of all seagrass species (Orth and Moore, 1984). In the 1970's the losses were greatest in the upper limits of the rivers, including the upper portion of Tangier Sound (Fishing Bay, Nanticoke River, Wicomico River, Monie Bay)

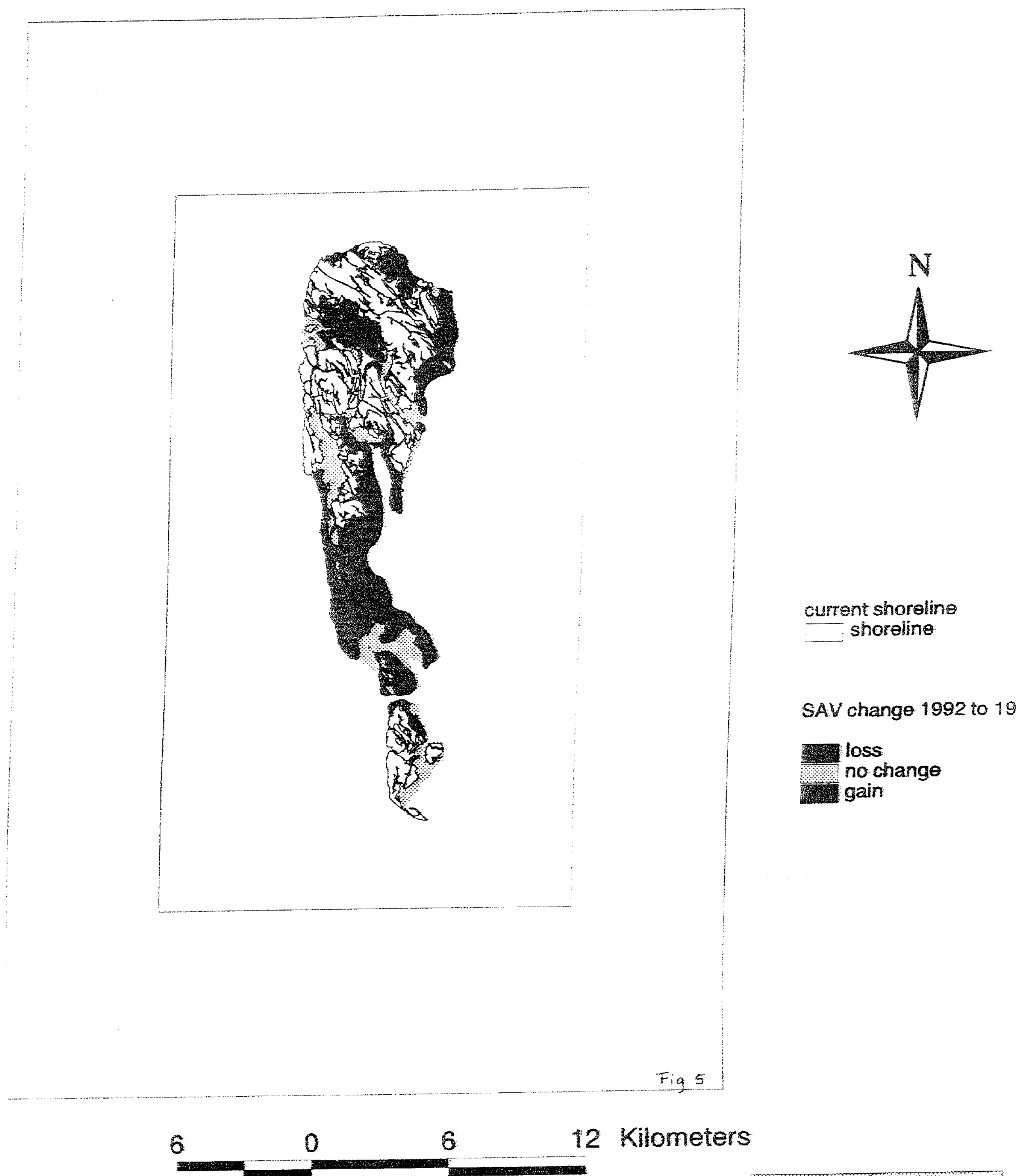
SAV Change 1992-1997 in the Smith Island Area

Fig 3

SAV Change from 1992 to 1997 in the Maryland Part of Smith Island

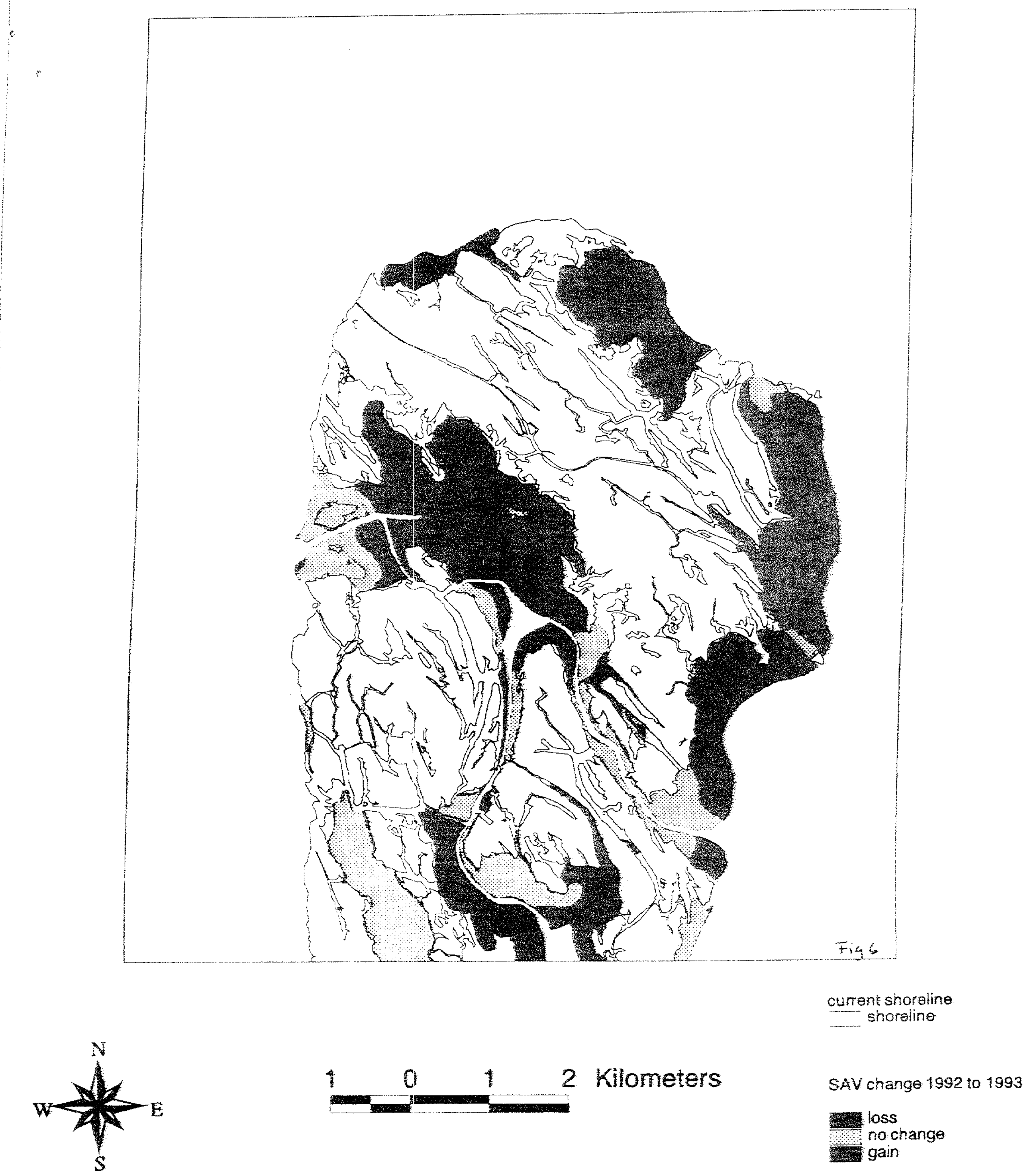


SAV Changes in the Smith Island Area 1992 to 199:

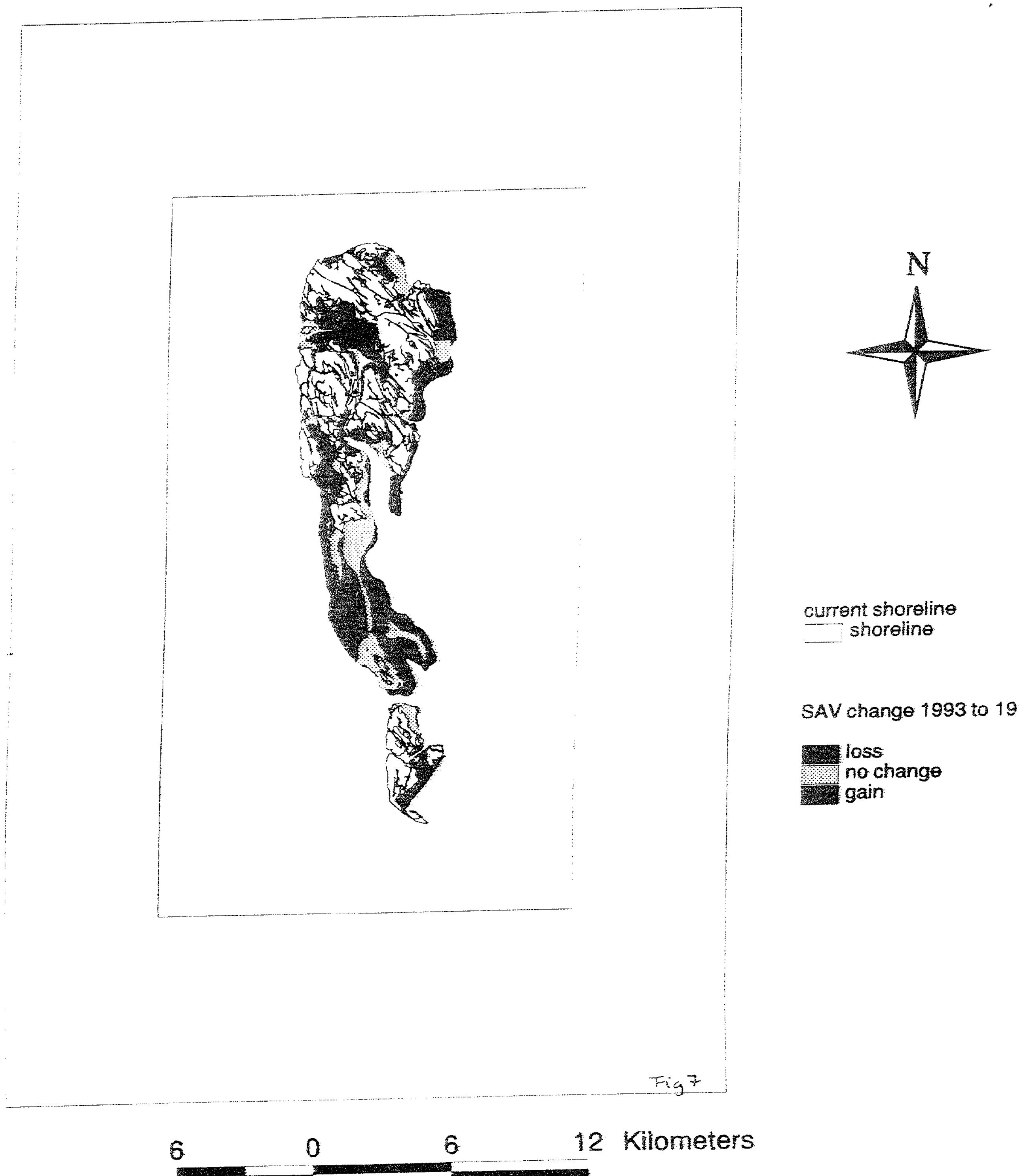


Change	Area (m2)
loss	24375700
no change	11988800
gain	12653600

SAV Change 1992-1993 in the Maryland Part of Smith Island

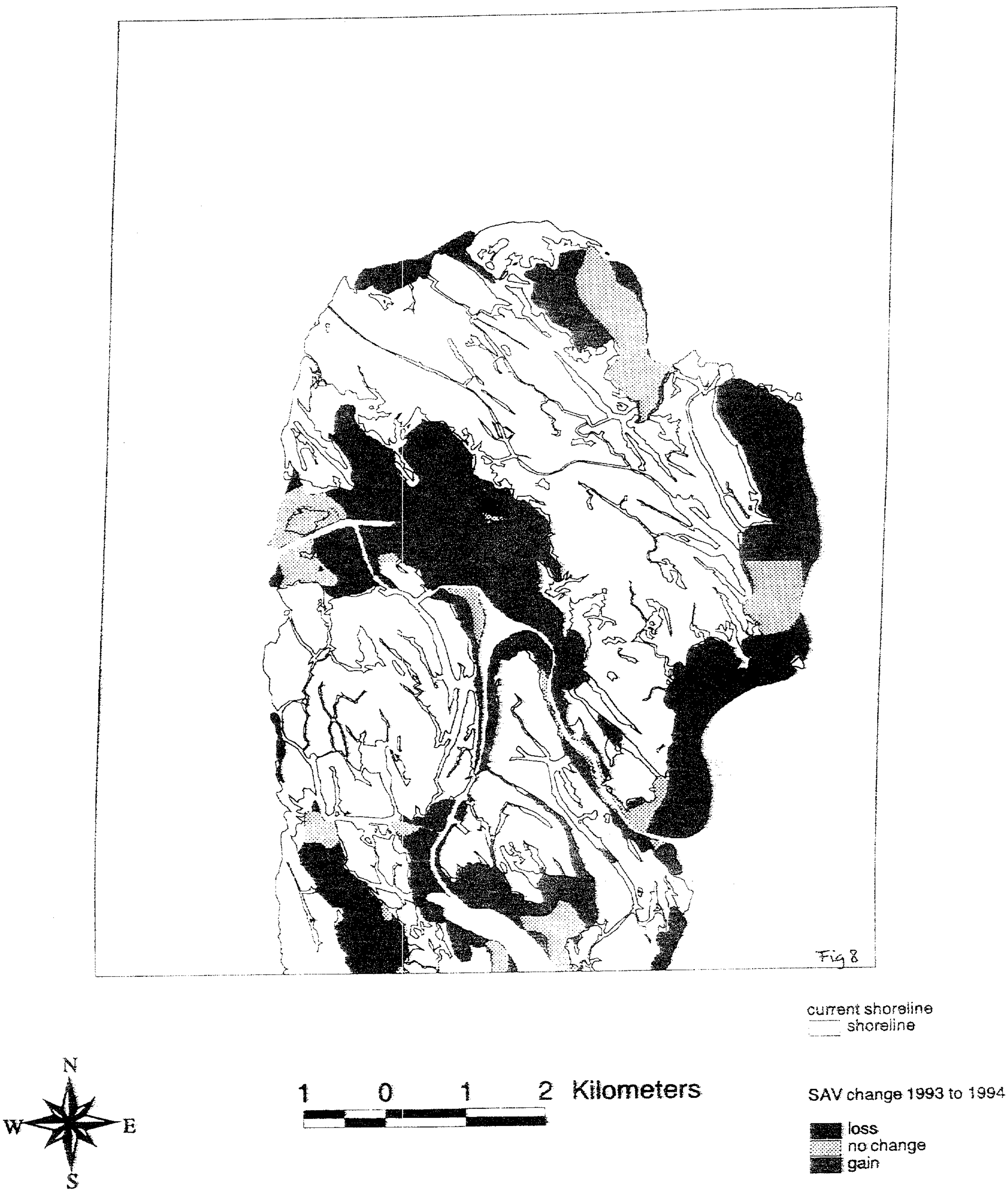


SAV change in the Smith Island Area 1993 to 1994



Change	Area (m2)
loss	21132100
no change	12021400
gain	12699300

SAV Change 1993-1994 in the Maryland Part of Smith Island



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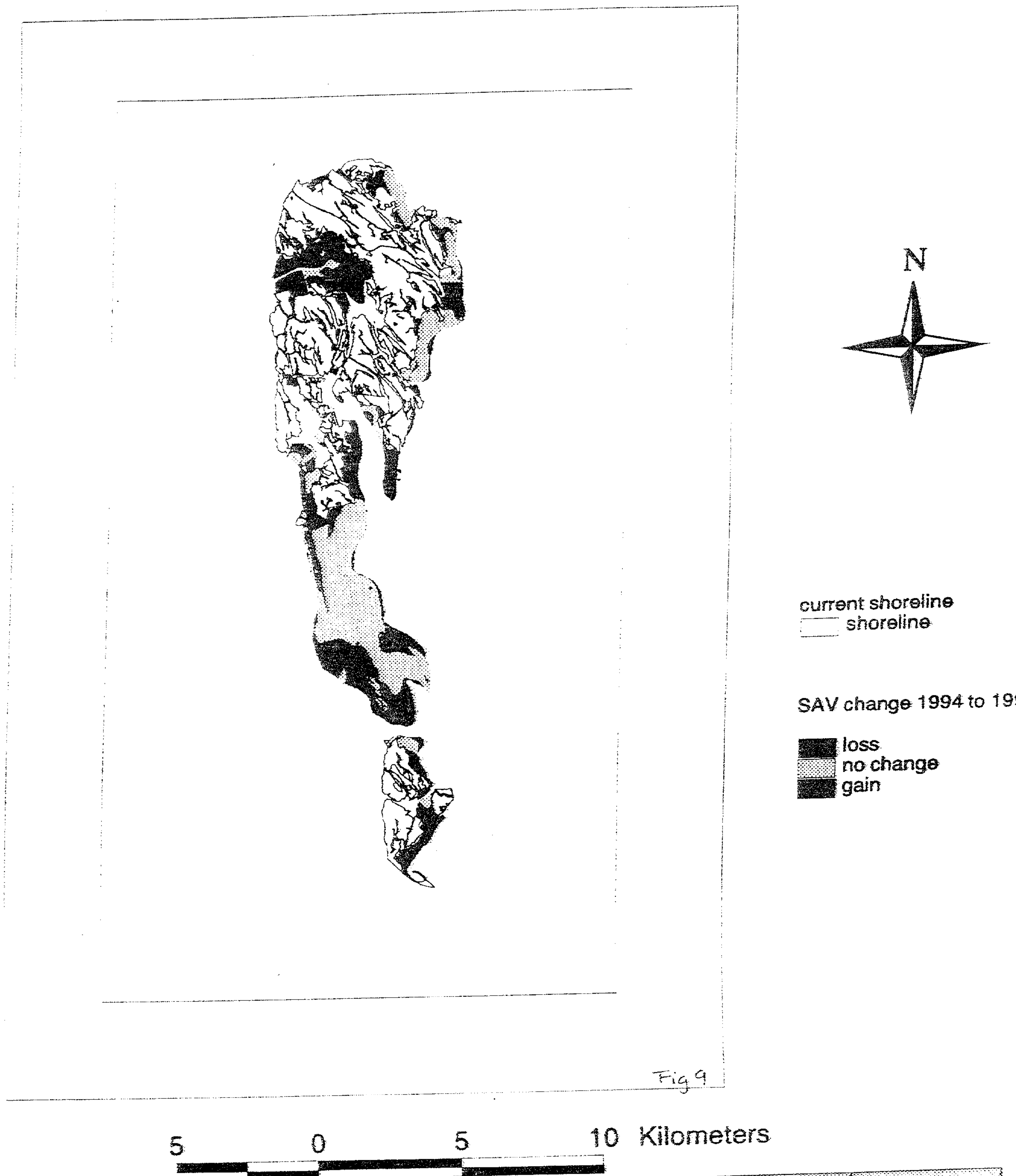


Change	Area (m2)
loss	10043100
no change	18234200
gain	8826000

SAV change in the Smith Island Area 1995 to 199

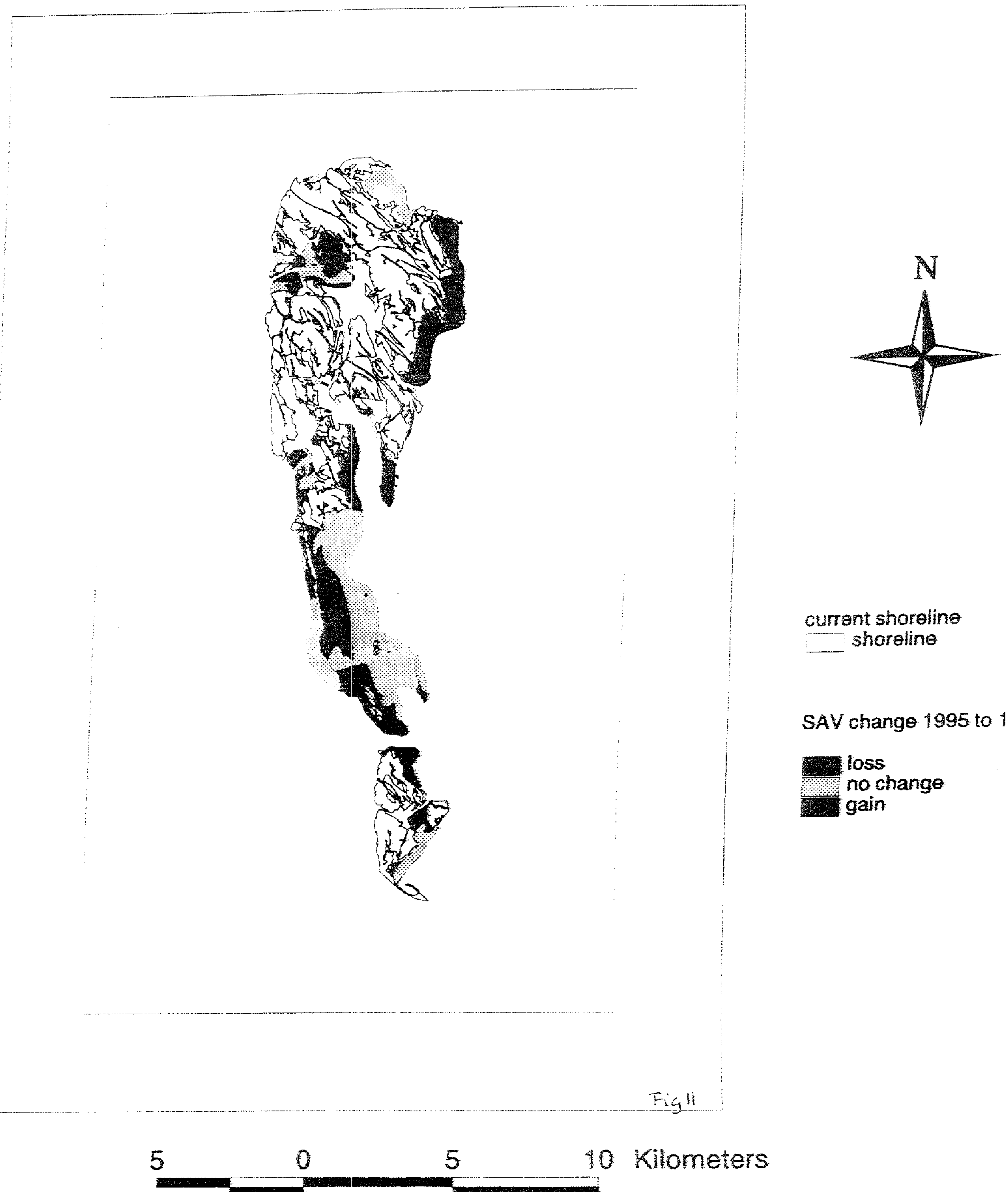
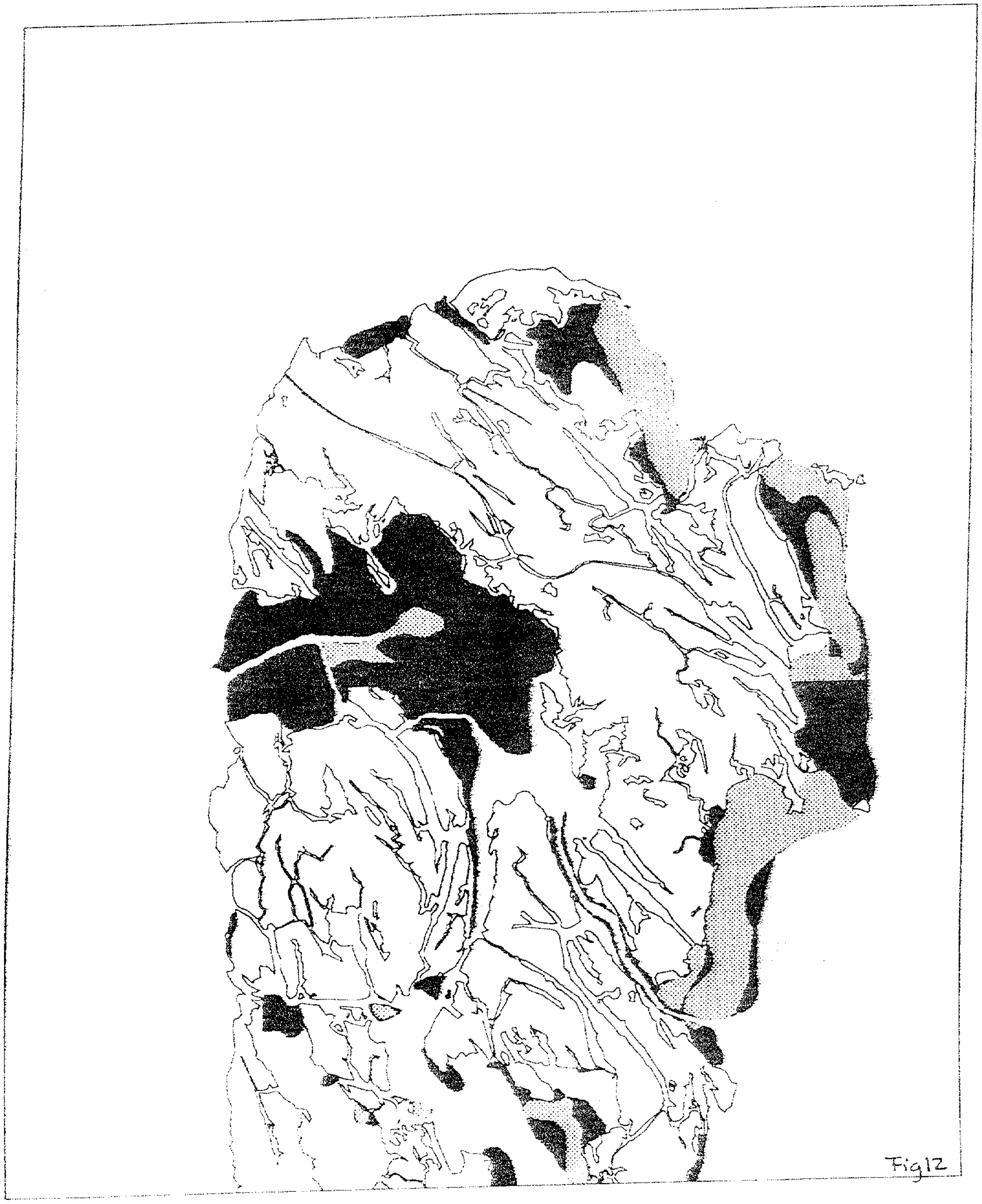


Fig 11

Change	Area (m2)
loss	9881600
no change	16036000
gain	7364300

SAV Change 1995-1996 in the Maryland Part of Smith Island



current shoreline
shoreline

N
W
E
S

1 0 1 2 Kilometers

SAV change 1994 to 1995
loss
no change
gain

SAV change in the Smith Island Area 1996 to 1997

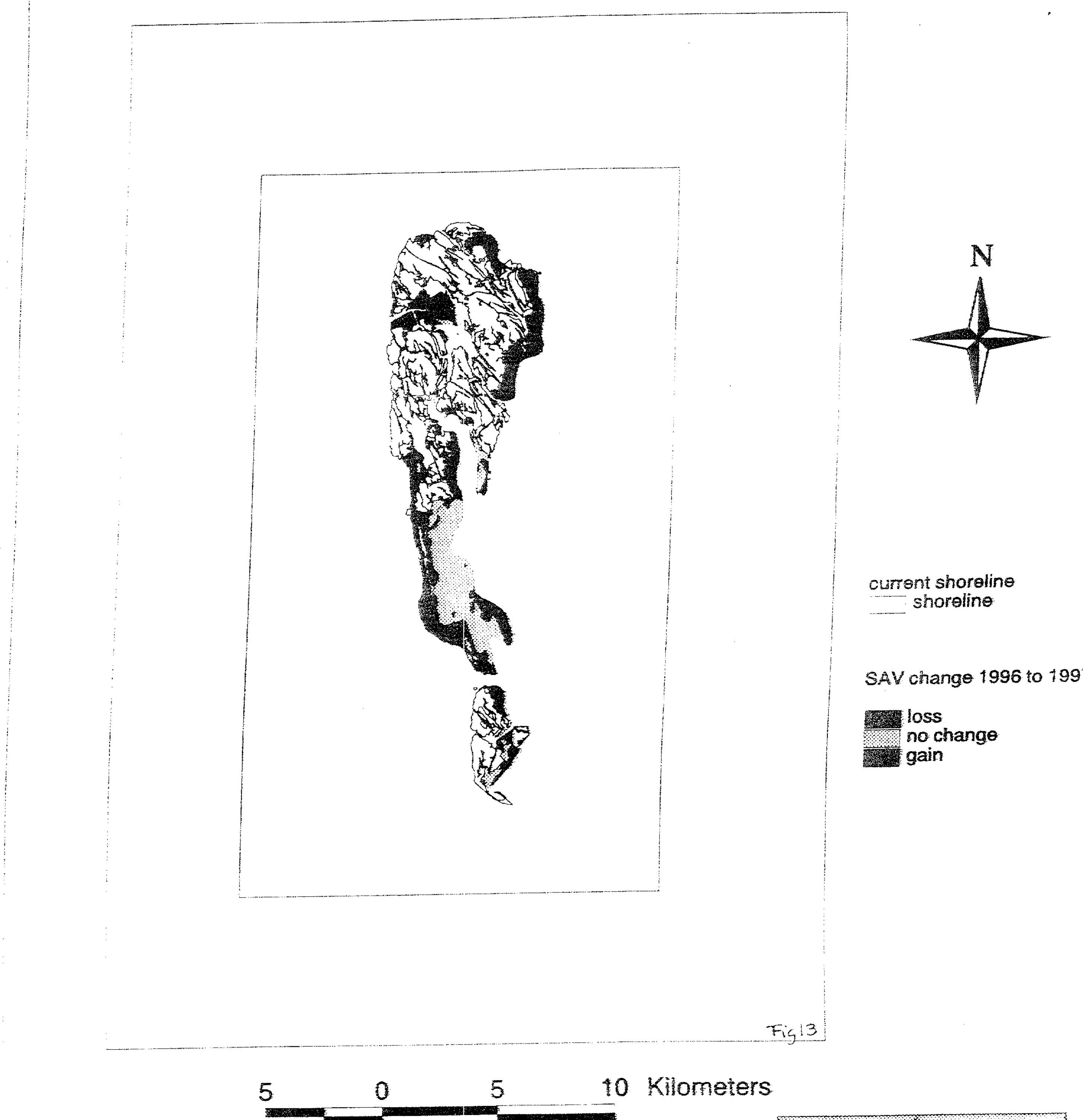
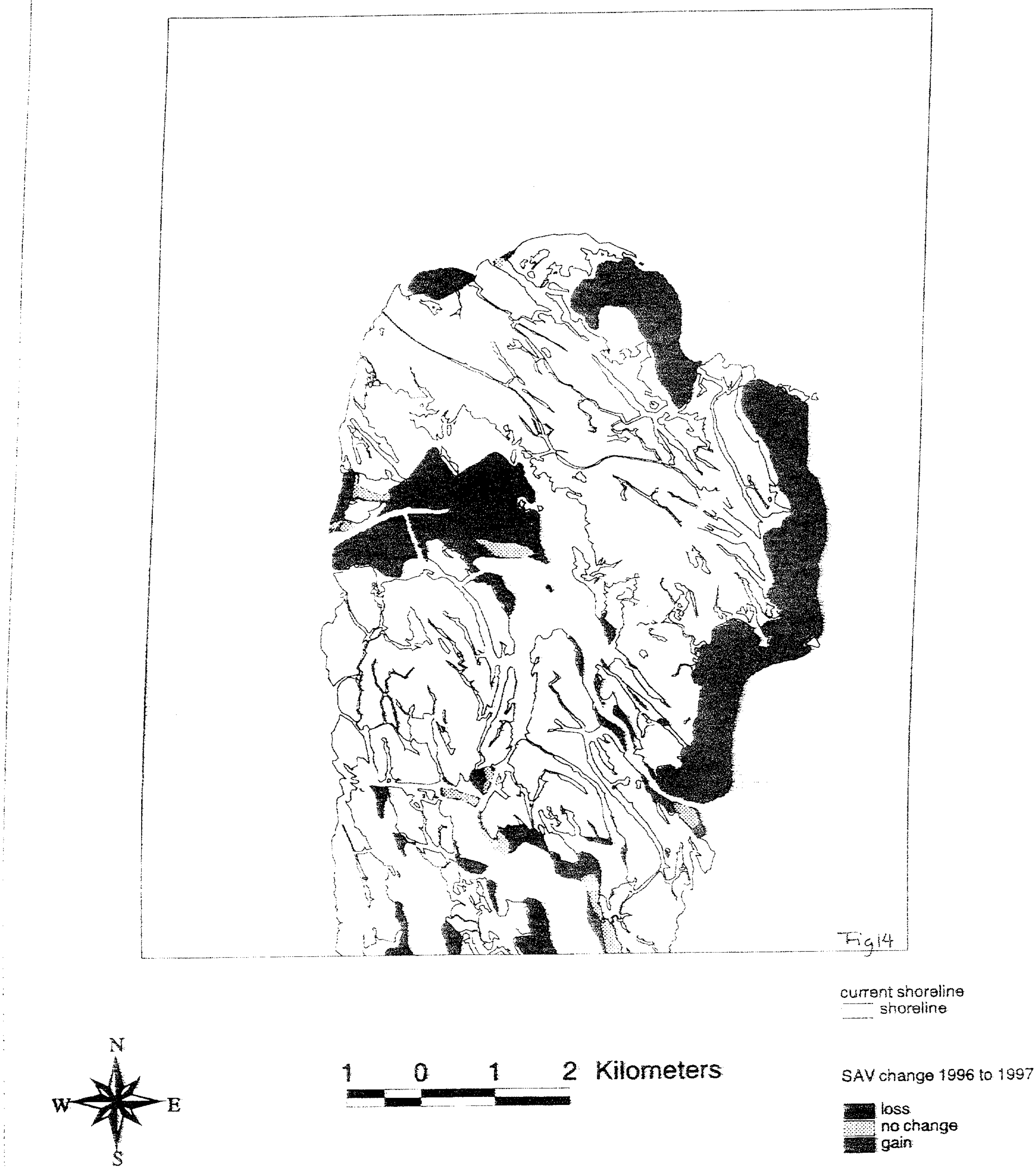


Fig 13

Change	Area (m2)
loss	14100100
no change	11718200
gain	8221800

SAV Change 1996-1997 in the Maryland Part of Smith Island



SAV Change in the Tylerton Area from 1992 to 199

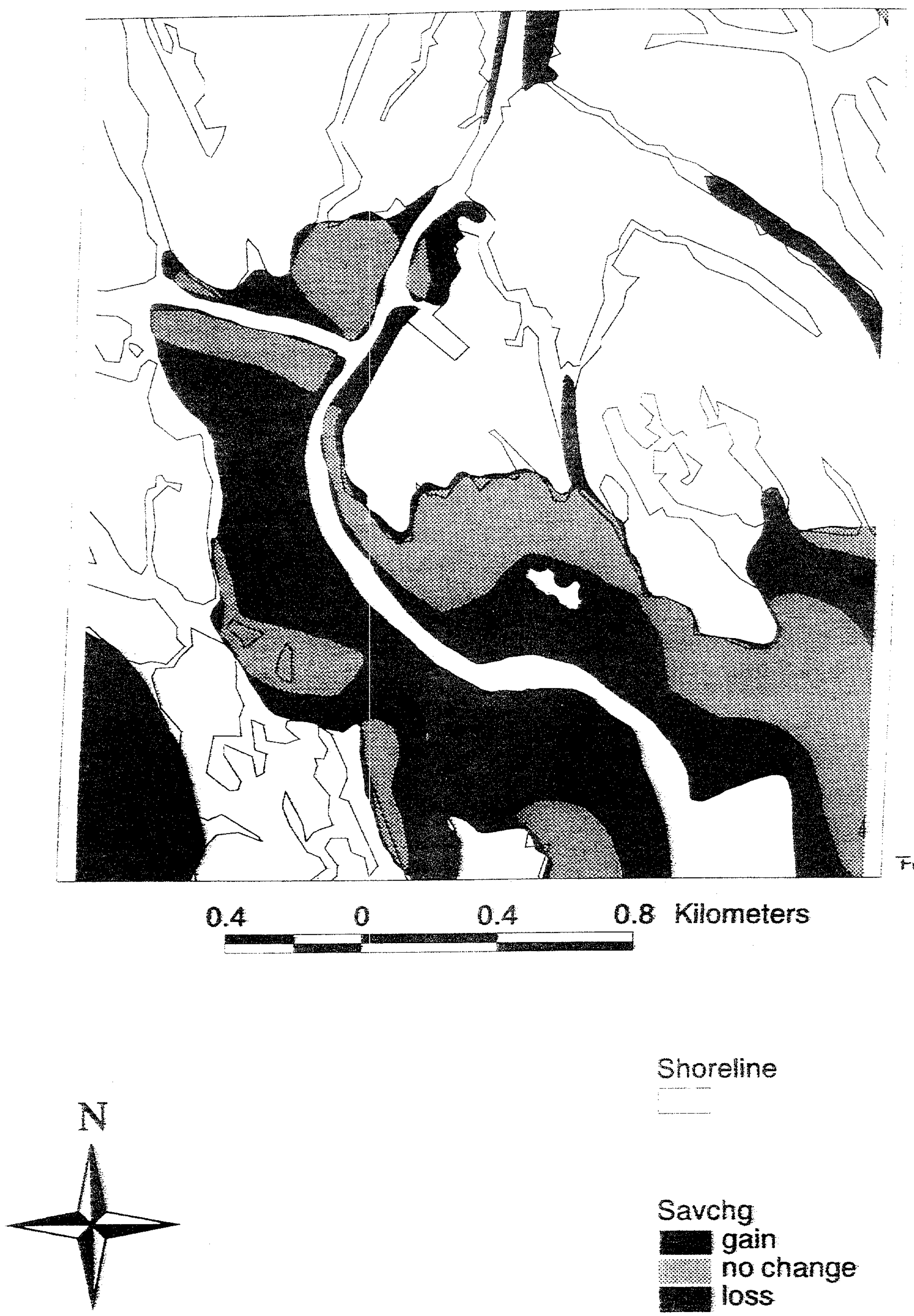
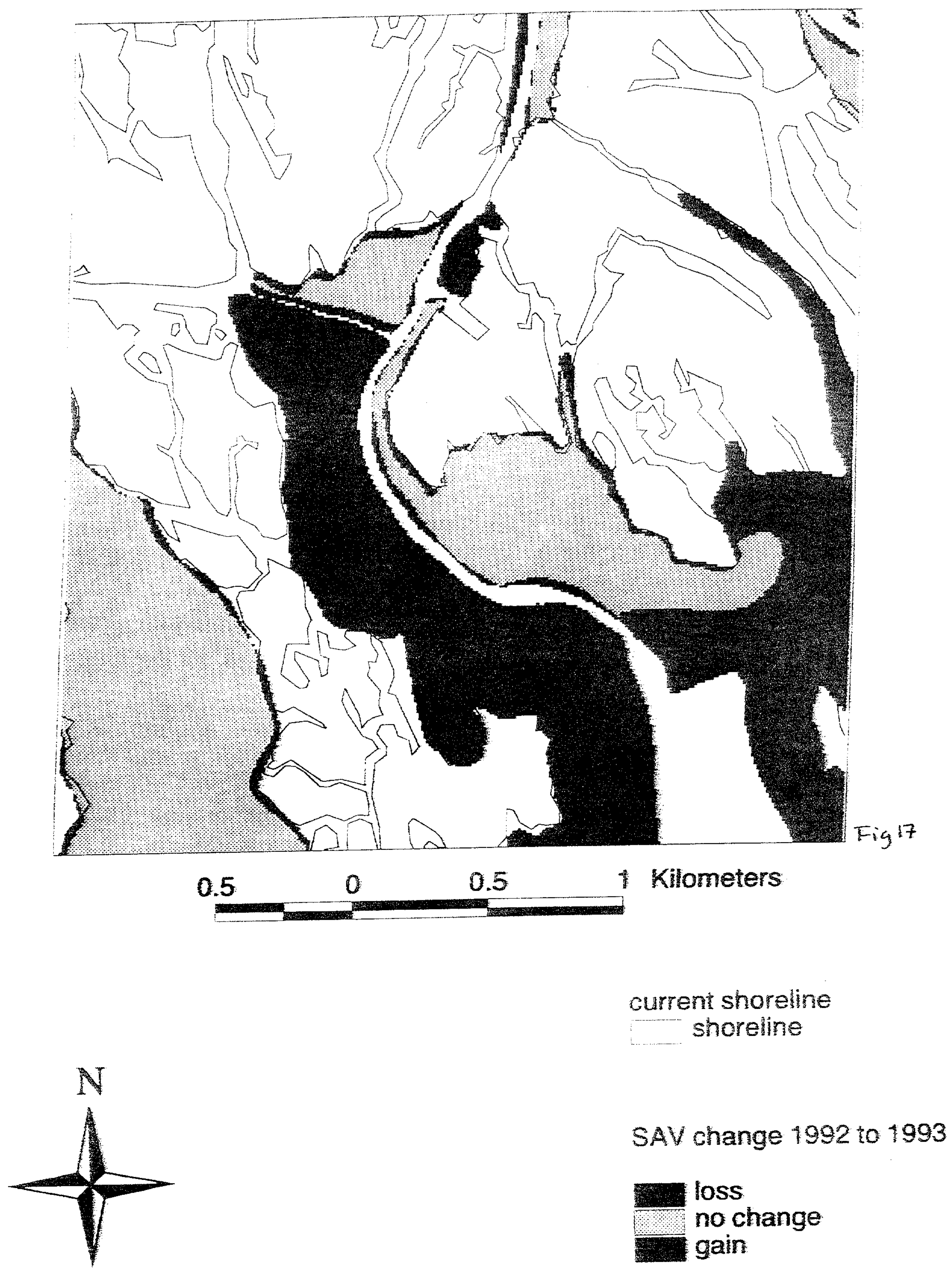


Fig16

SAV Change in the Tylerton Area 1992 to 1993



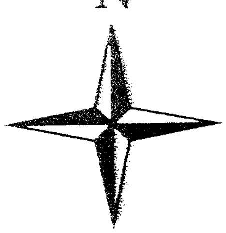
SAV Change in the Tylerton Area 1993 to 1994

Fig 18

0.5 0 0.5 1 Kilometers

current shoreline
shoreline

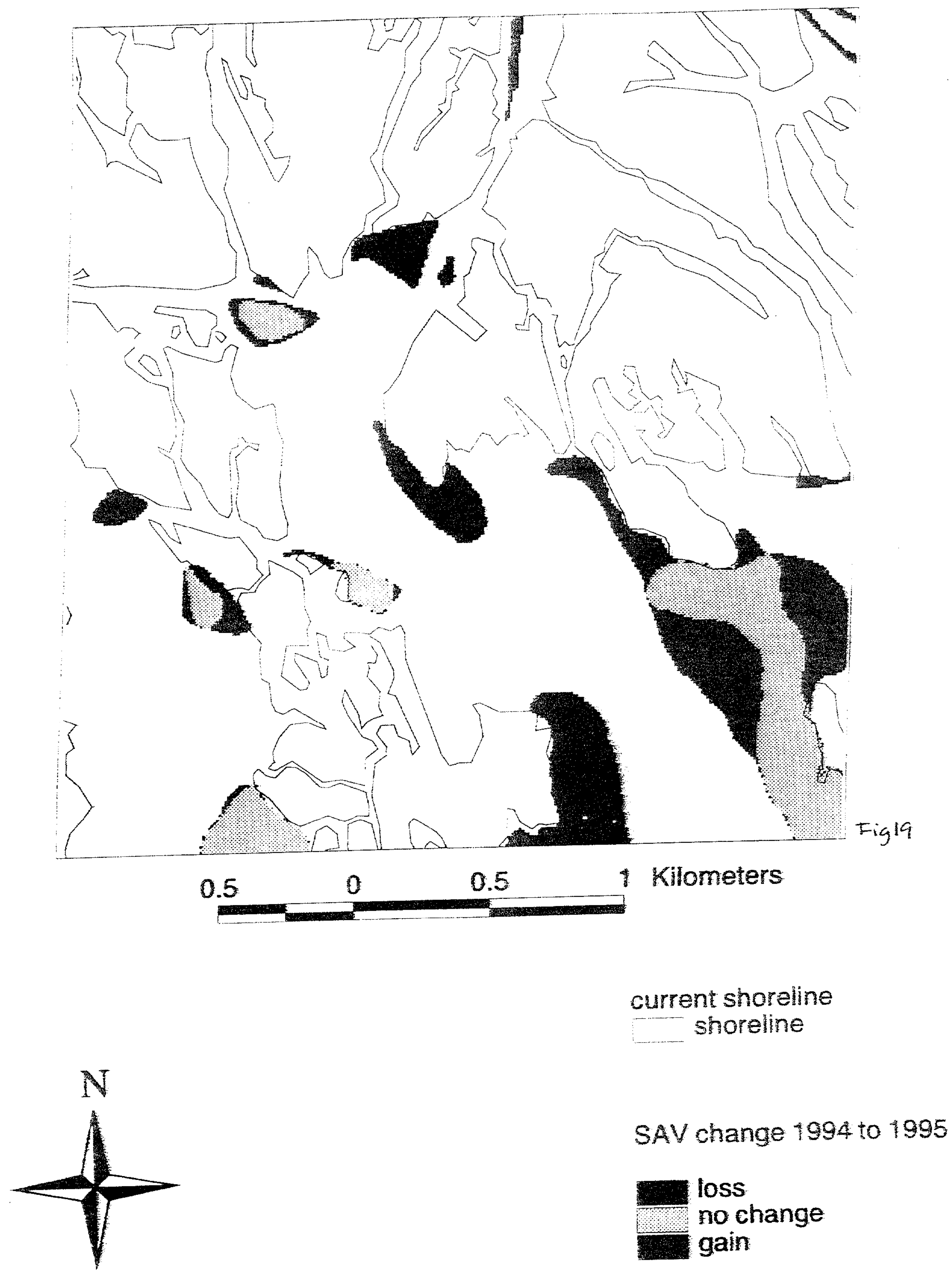
N



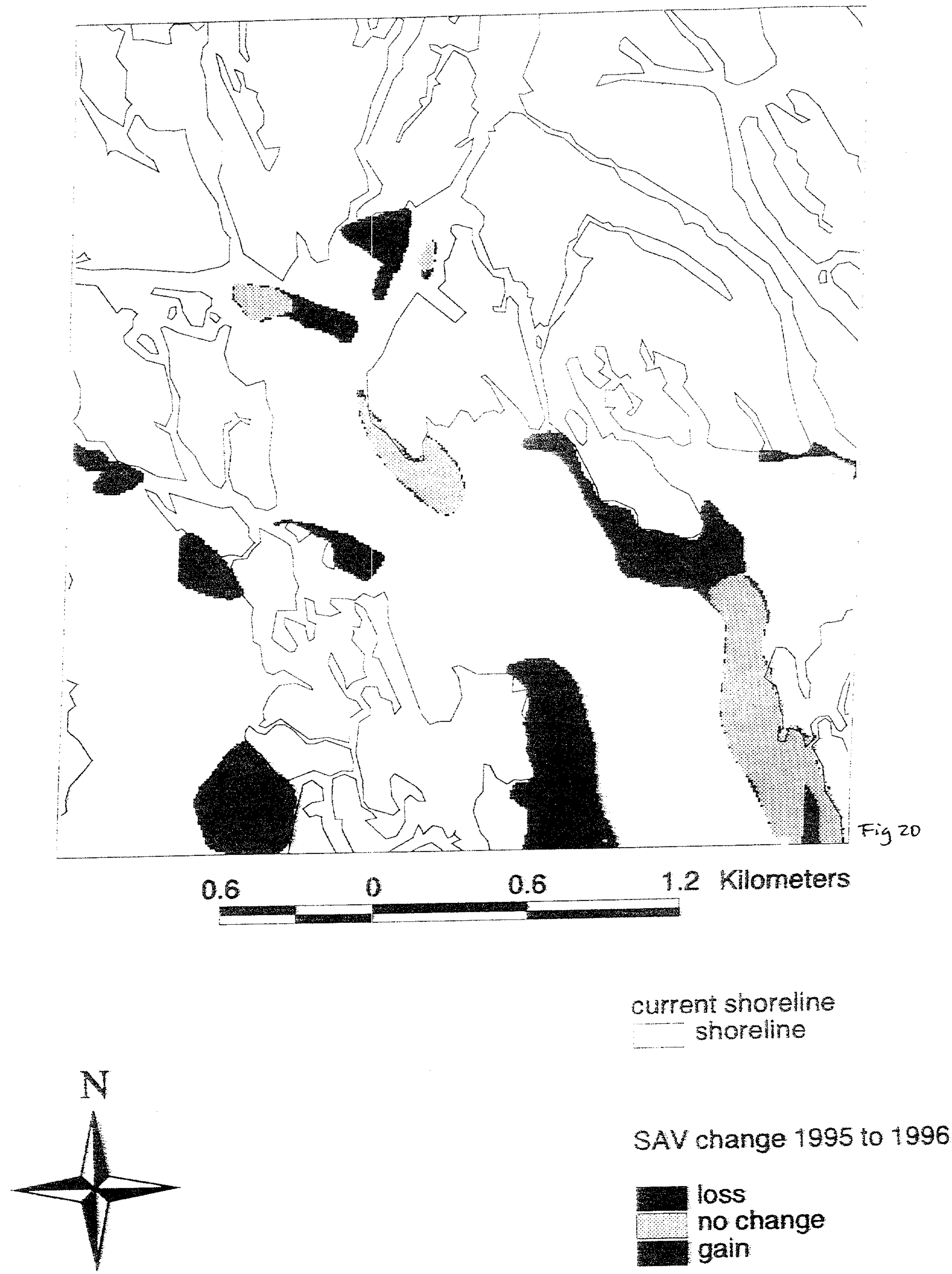
SAV change 1993 to 1994

loss
no change
gain

SAV Change in the Tylerton Area 1994 to 1995



SAV Changes in the Tylerton Area 1995-1996



SAV Change in the Tylerton Area 1996 to 1997

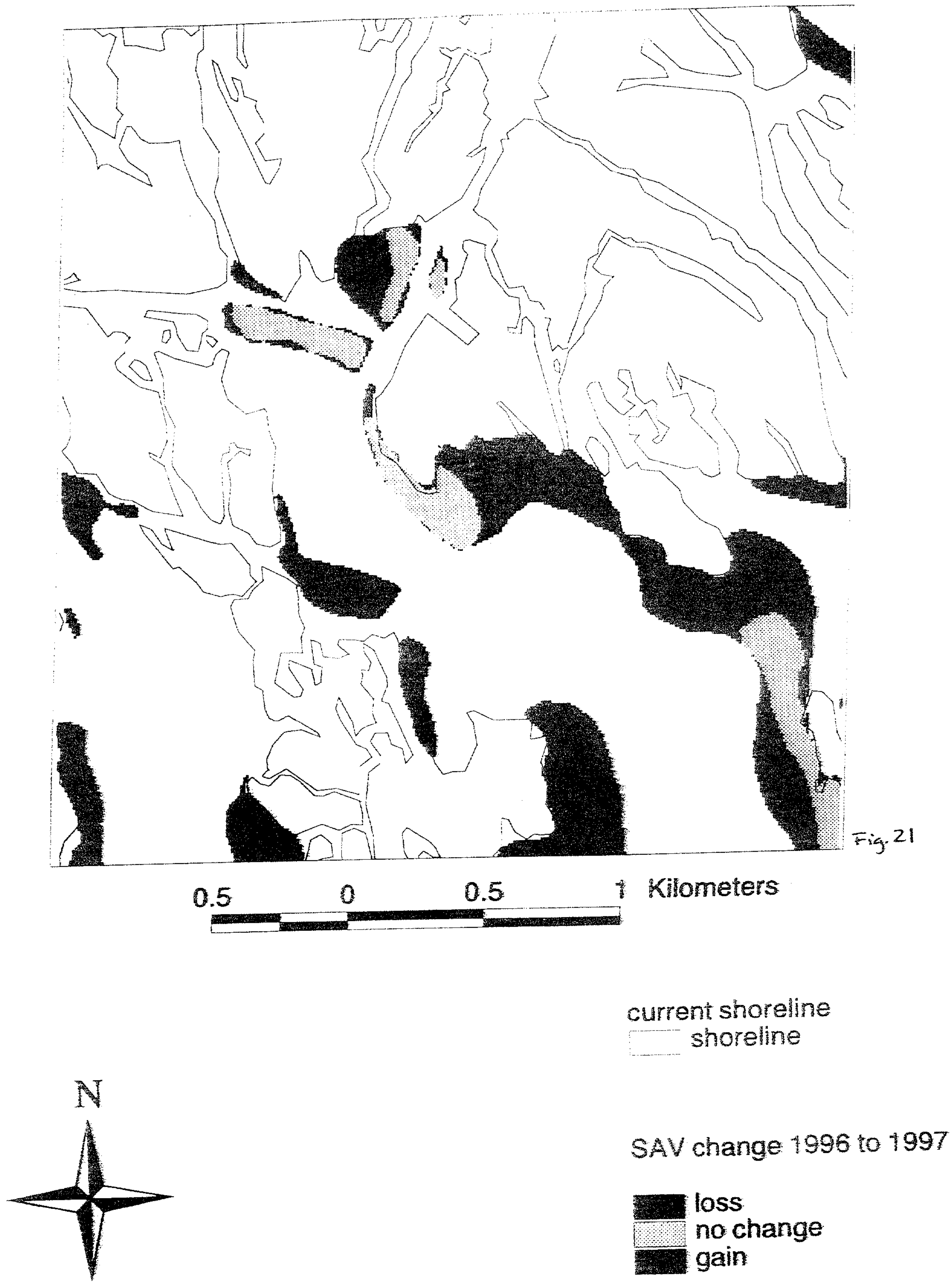


Fig. 21

SAV Changes in the Sheep Pen Gut Area from 1992 to 1997

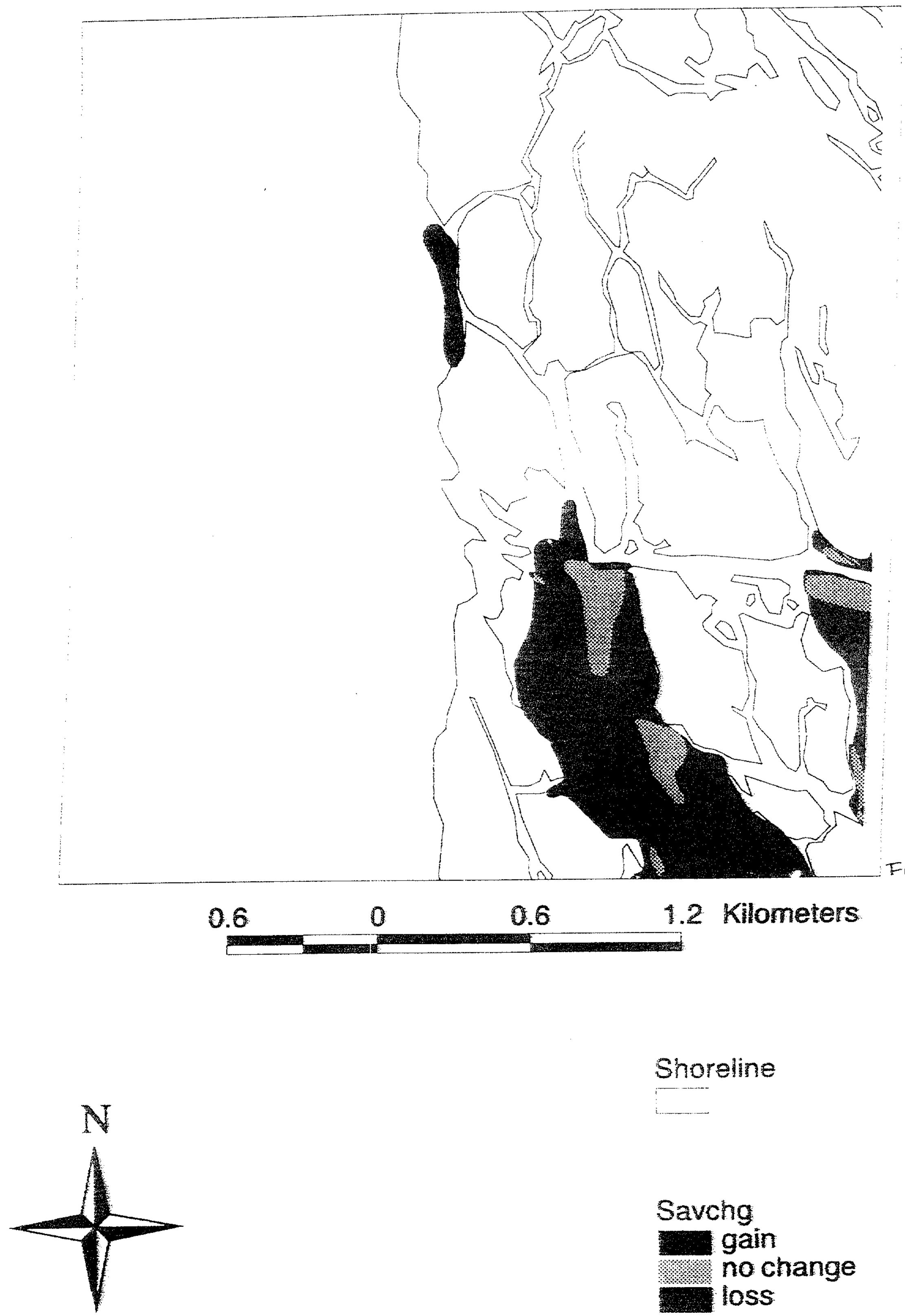
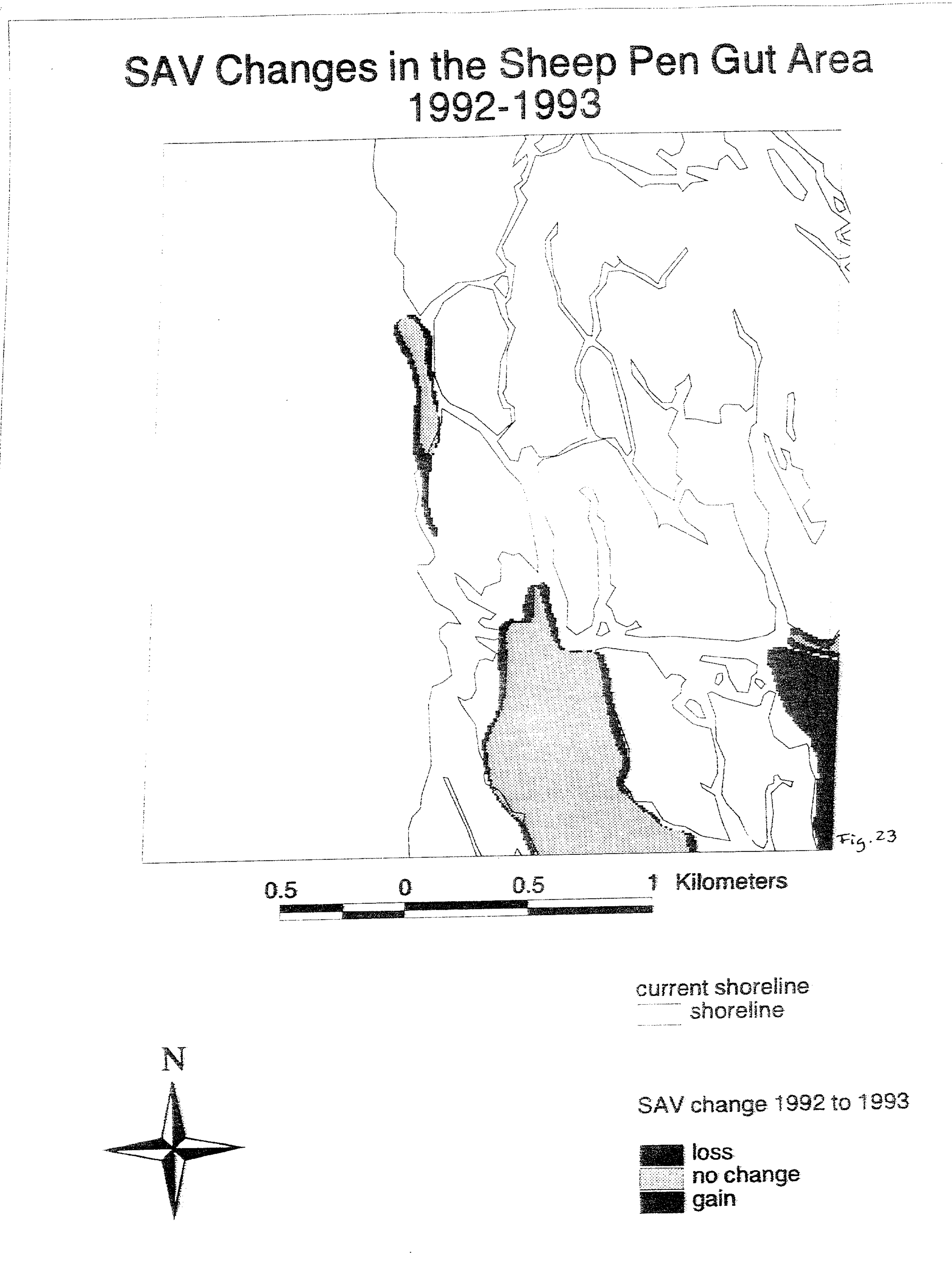
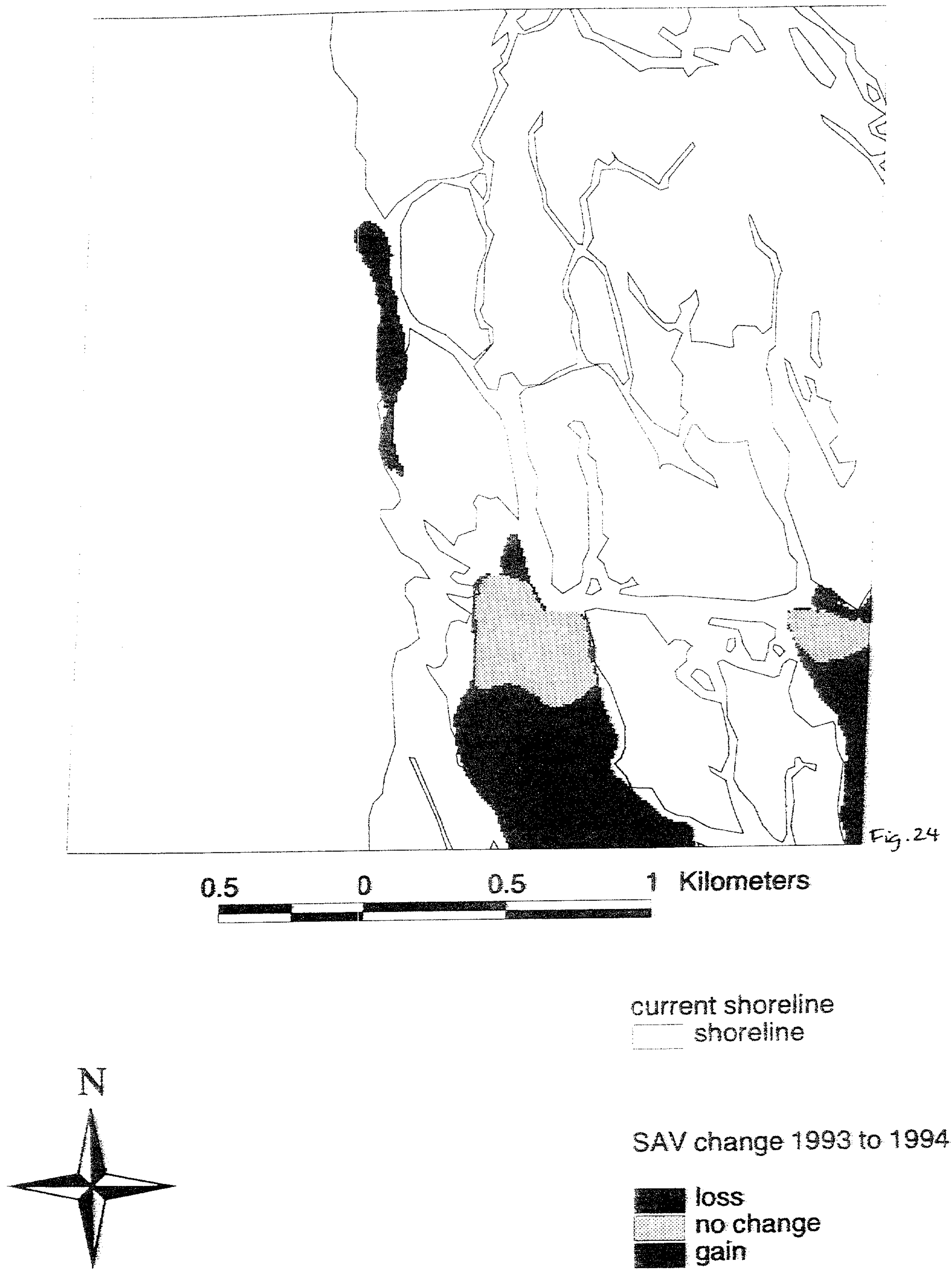


Fig. 22


SAV Changes in the Sheep Pen Gut Area
1992-1993
Fig. 23
0.5
0
0.5
1 Kilometers
current shoreline
shoreline
N
SAV change 1992 to 1993
loss
no change
gain

SAV Changes in the Sheep Pen Gut Area
1993-1994



SAV Changes in the Sheep Pen Gut Area
1994-1995

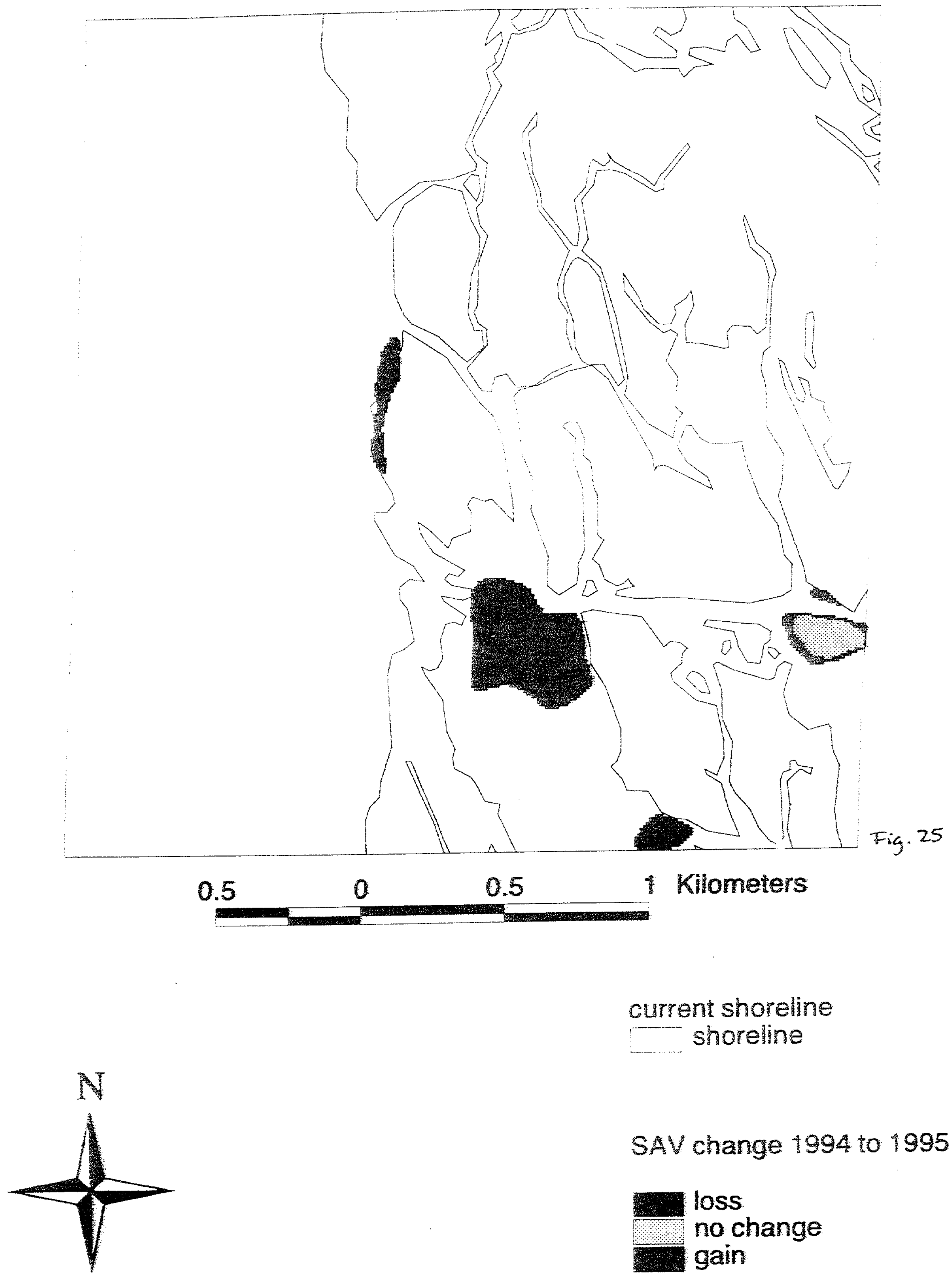


Fig. 25

SAV Changes in the Sheep Pen Gut Area 1995-1996

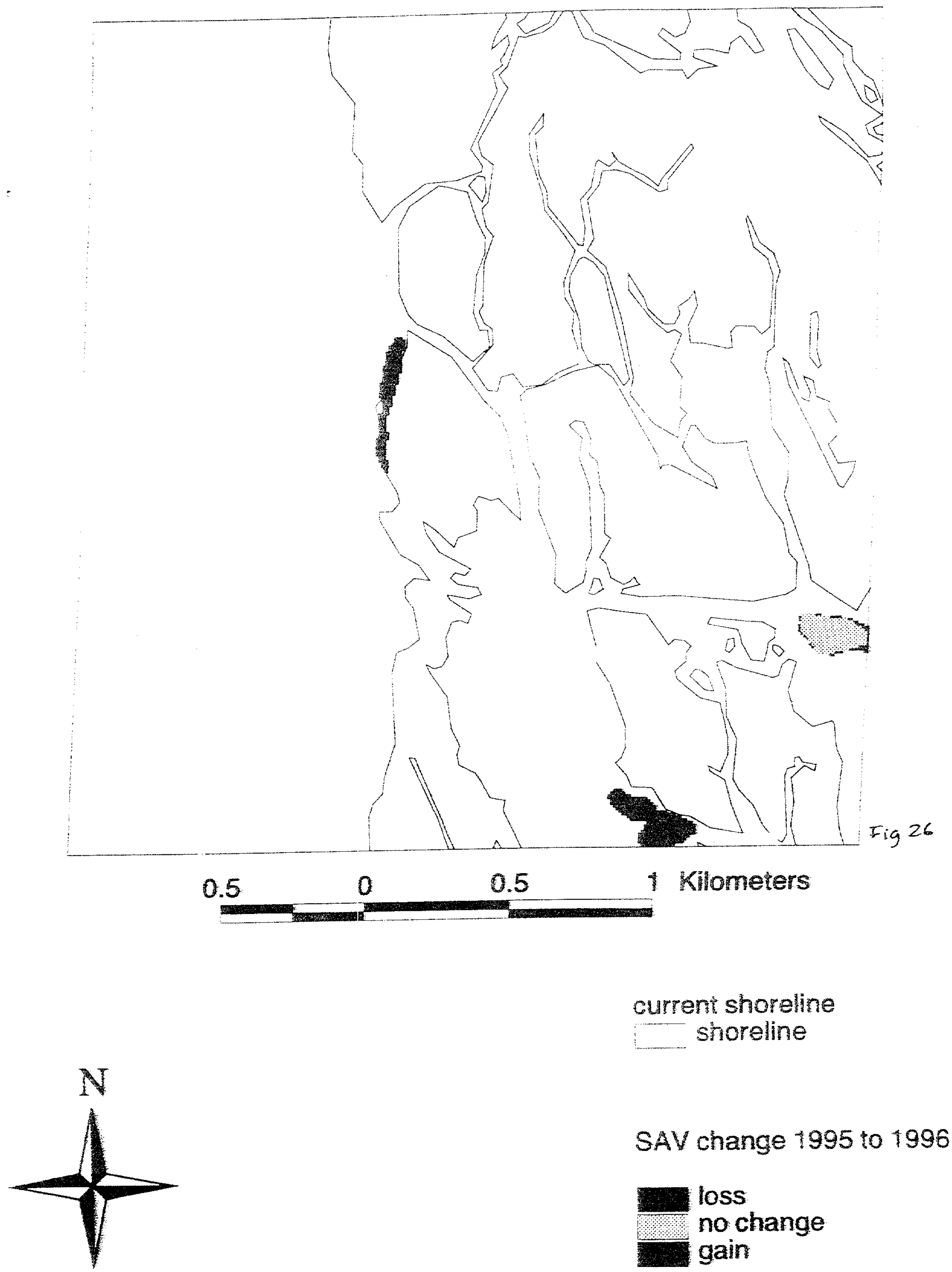


Fig 26

SAV Changes in the Sheep Pen Gut Area 1996-1997

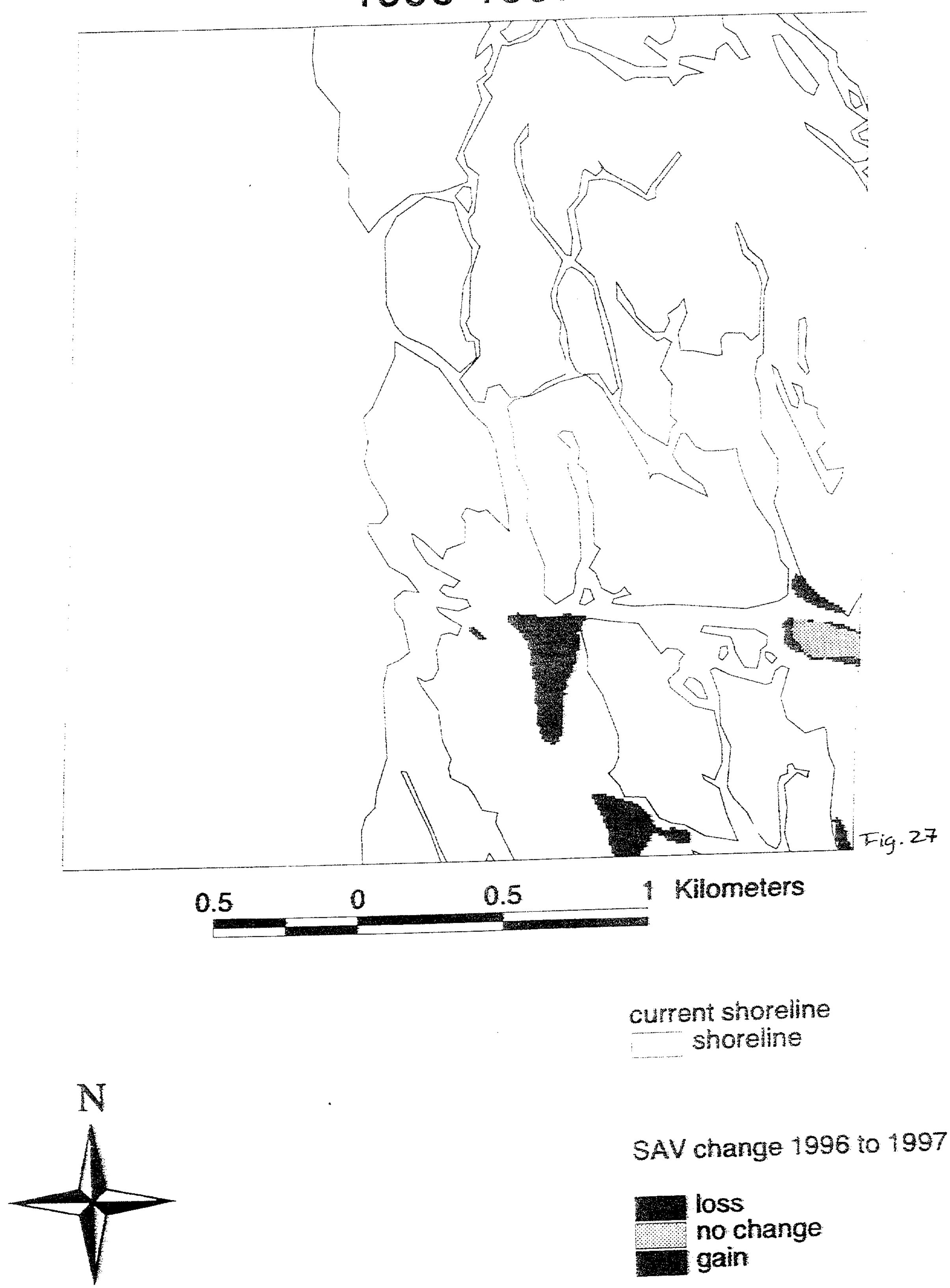


Fig. 27

25) and only a small portion recovered two years later (Figs. 26, 27). Preliminary data for 1998 indicates that this bed still existed at that time.

Swan Island

The areas west, southwest and north of Swan Island has experienced little change in seagrass coverage between 1992 and 1997 and there has actually been some expansion of the grass beds onshore (Fig. 28). Again, this may be a result of coastal erosion, transforming previously emerged areas into habitats suitable for SAV growth (i.e. sub-tidal).

Between 1992 and 1993, little change occurred around Swan Island but in Big Thoroughfare, one area recovered while another one was being lost (Fig. 29). The area that was being lost is the one nearest to a breach and may be due to increased sediment transport since the breach was formed. Between 1993 and 1994, still no change around Swan Island was observed (except for the loss of the northern most tip of that bed) and the area in Big Thoroughfare that had recovered in the previous year, disappeared again (Fig. 30). Between 1994 and 1995, a massive decline in seagrasses around Swan Island and in Big Thoroughfare was observed (Fig. 31) but the next year, a large portion of that area recovered (Fig. 32) but not the areas south and east of Swan Island. The area west of Swan Island was lost in 1997 (Fig. 33) but recovered in 1998 and 1999 (preliminary data).

Fog Point Cove

Over a 5 year period (1992-1997) this area showed a decline in coverage of the seagrasses in the deeper areas but also an increase in seagrass coverage in these deeper areas (Fig. 34) which makes it difficult to interpret the cause for the loss of the vegetation. All the submersed vegetation in this area showed a significant decline in coverage between 1992 and 1993 (Fig. 35). The next year, the seagrasses recovered in the shallower areas (Fig. 36) and the year after that, their coverage improved even further in some of the deeper areas (Fig. 37). In 1996 (Fig. 38) and 1997 (Fig. 39) the bed continue to become thicker but never reached the same degree of coverage that it had in 1992. Preliminary data indicates that in 1999, this bed expanded even further but is still smaller than the 1992 bed.

Back Cove

A significant loss in seagrass coverage in the west portion (as well as some areas in the southeast and northeast) of Back Cove has occurred between 1992 and 1997 (Fig. 40). Initially, most of the submersed vegetation in this area showed a signioficant decline in coverage between 1992 and 1993 (Fig. 41) but a large portion of it recovered the next year (Fig. 42). Between 1994 and 1995, the main losses occurred landward (Fig. 43) but the entire cove recovered the following year (Fig. 44) only to disappear again the next year (Fig. 45). Preliminary data for 1998 shows the recovery of the vegetation in almost the entire cove and the preliminary data for 1999 shows a cove completely recolonized by seagrasses.

This fluctuation in seagrass coverage (complete loss in 1993 and 1997 but complete recovery 2 or 3 years later) is typical for Ruppia maritima (Widgeon grass) which colonizes Back Cove. It tends to come and go without any apparent reasons and is

SAV Change from Swan Island to the Breach from 1992 to 1997

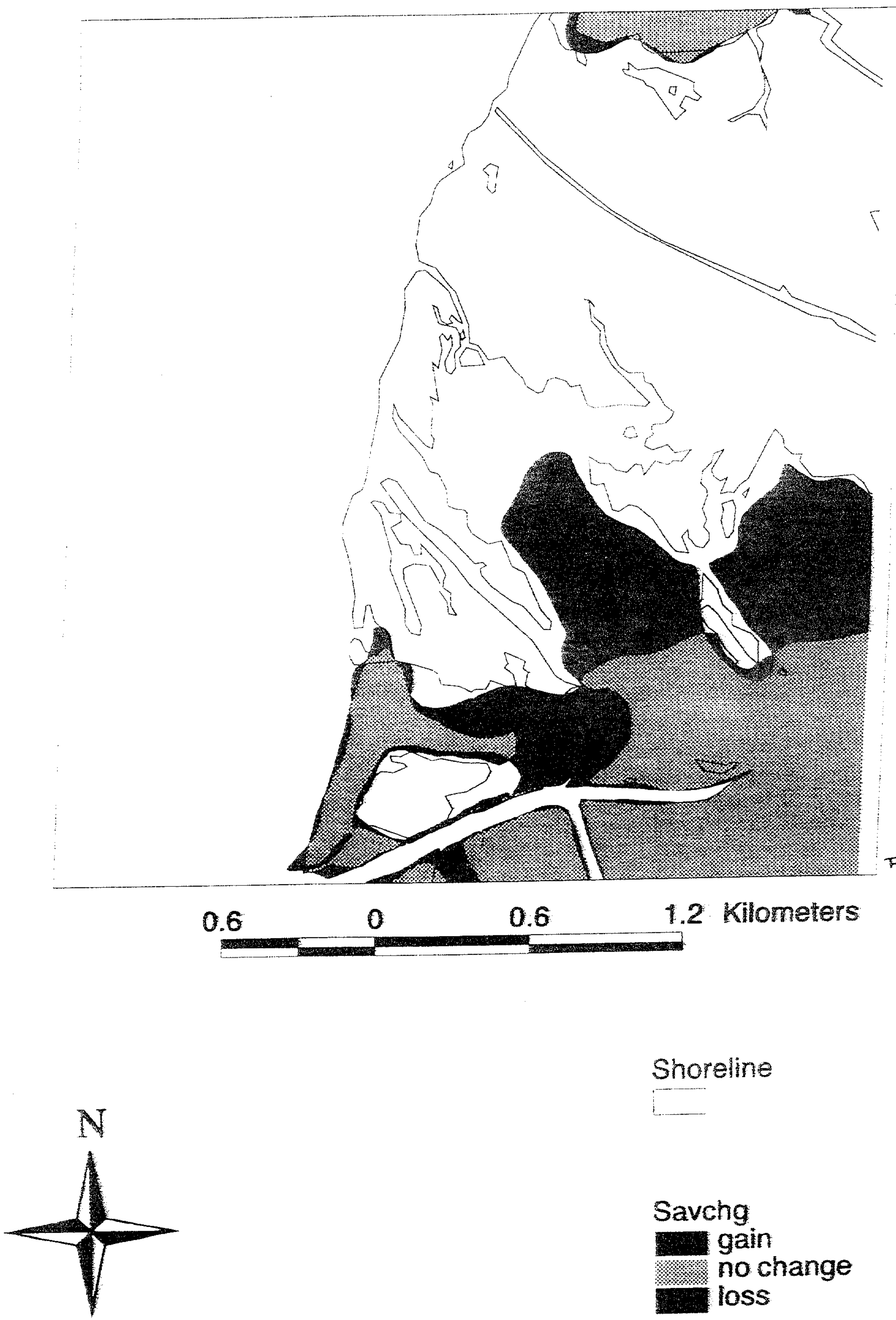


Fig. 28

SAV Change from Swan Island to the Breach 1992-1993

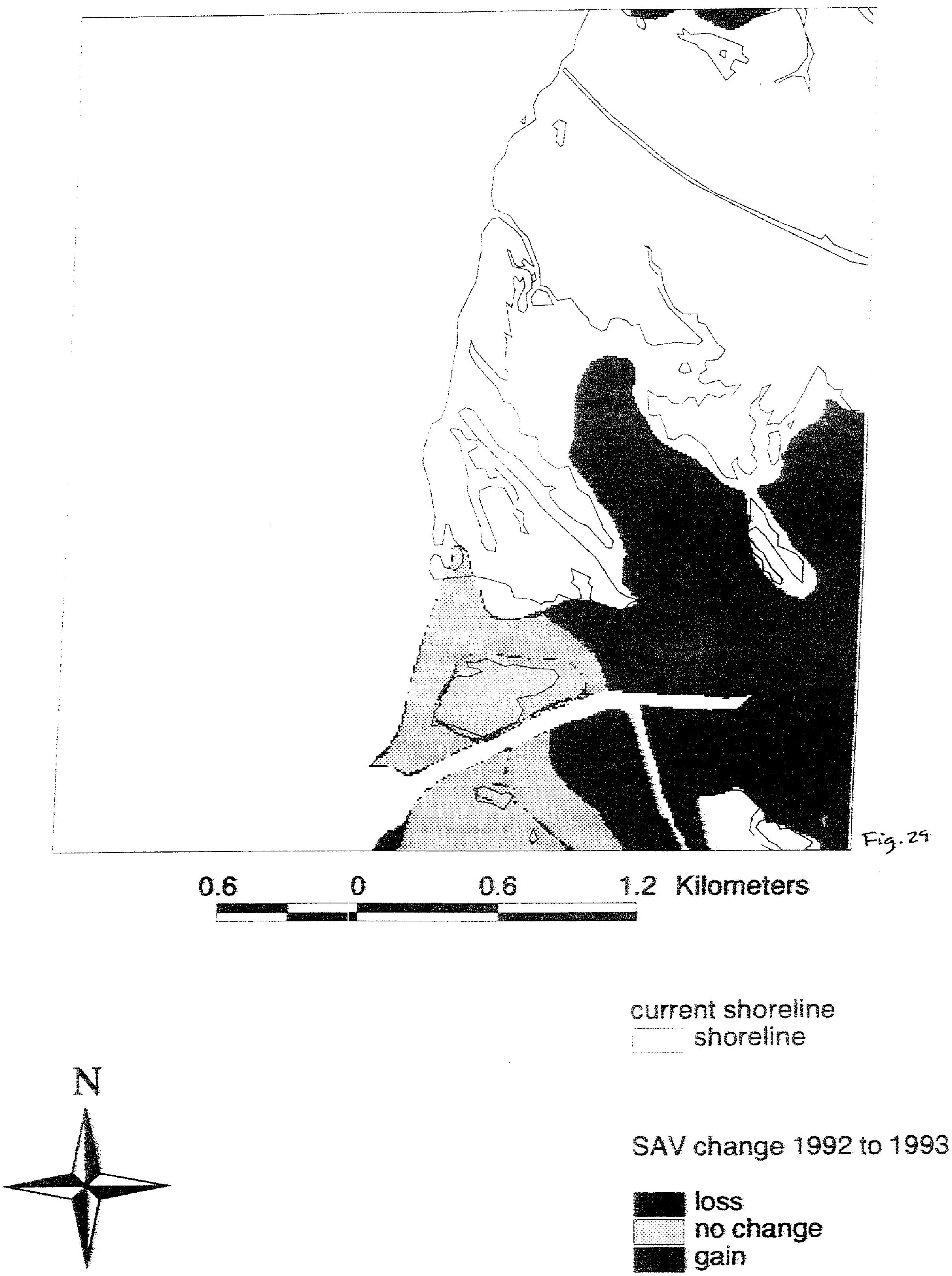


Fig. 29

SAV Change from Swan Island to the Breach 1993-1994

Fig. 30

0.6 0 0.6 1.2 Kilometers

current shoreline
shoreline

N

SAV change 1993 to 1994

loss
no change
gain

SAV Change from Swan Island to the Breach 1994-1995

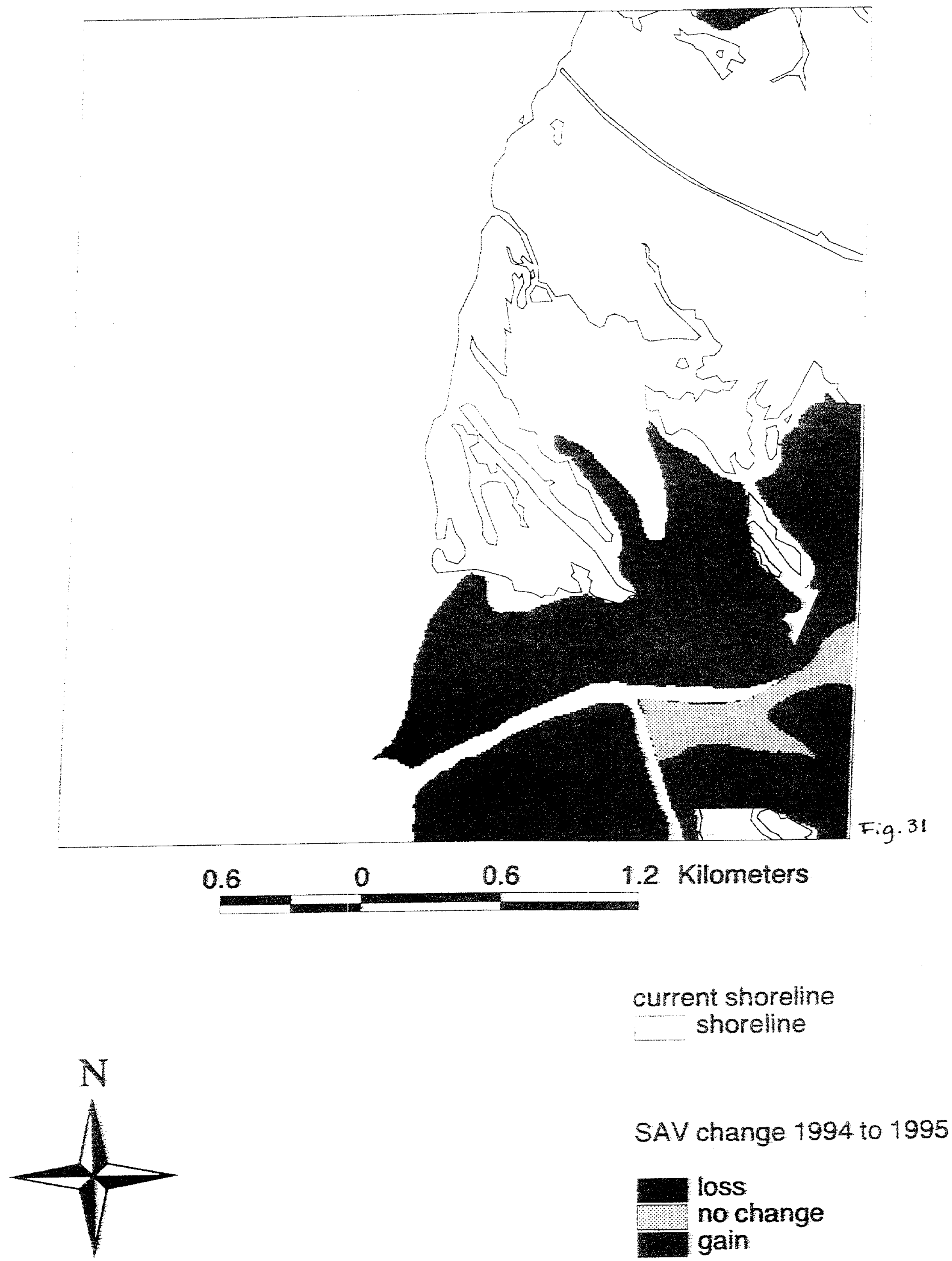


Fig. 31

SAV Change from Swan Island to the Breach 1995-1996

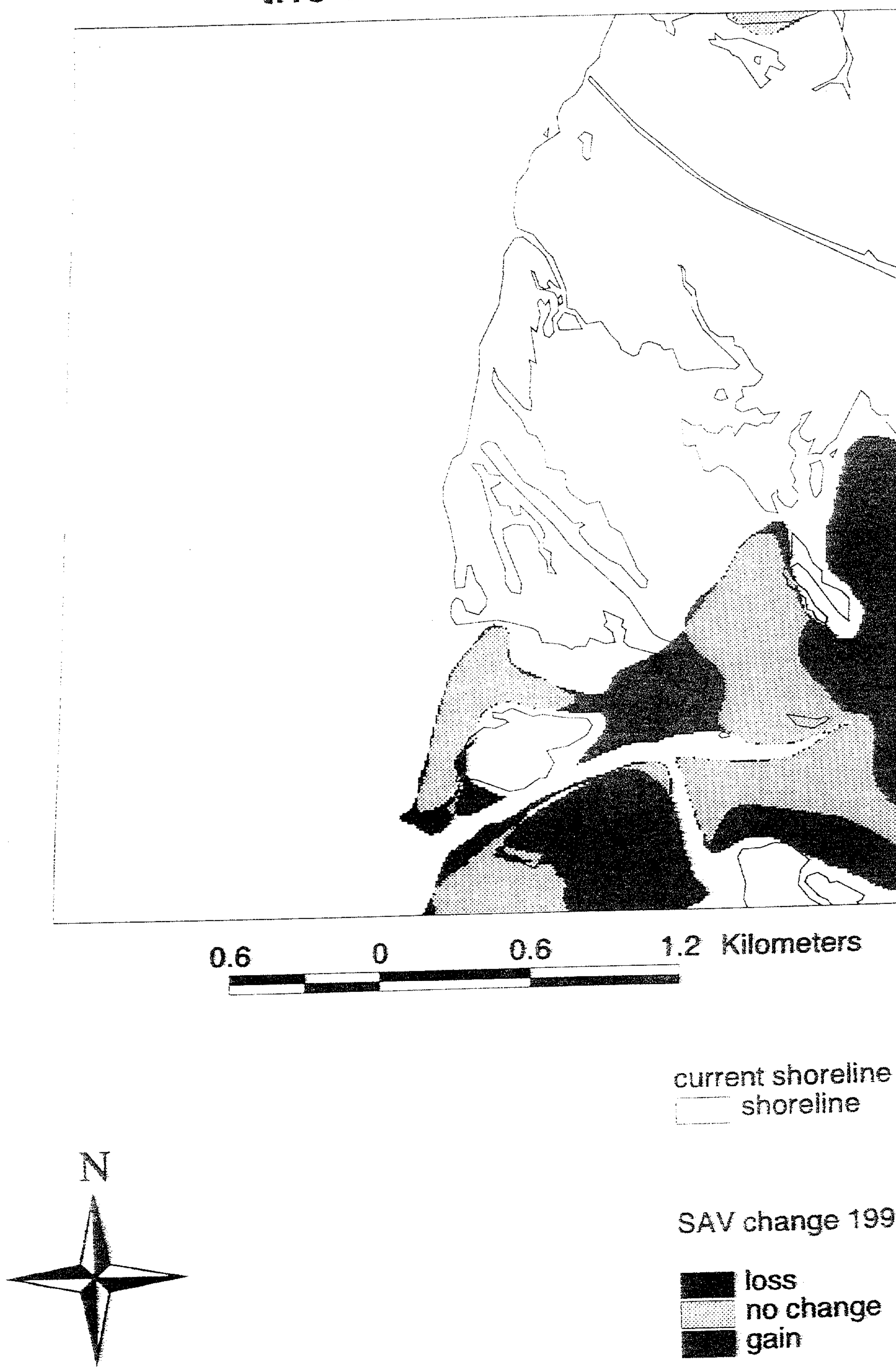


Fig 32

SAV Change from Swan Island to the Breach 1996-1997

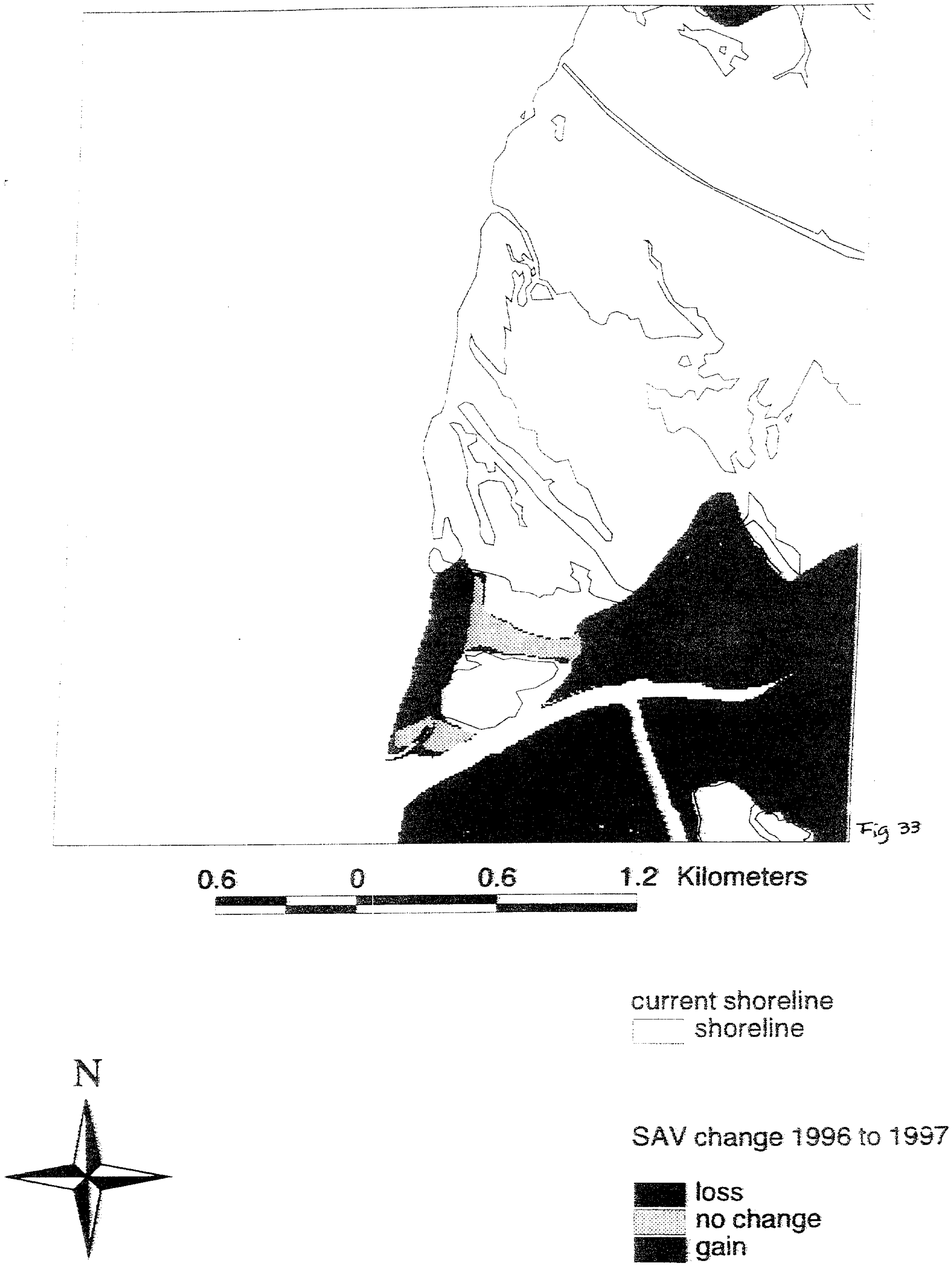


Fig 33

SAV Change in Fog Point Cove from 1992 to 1997

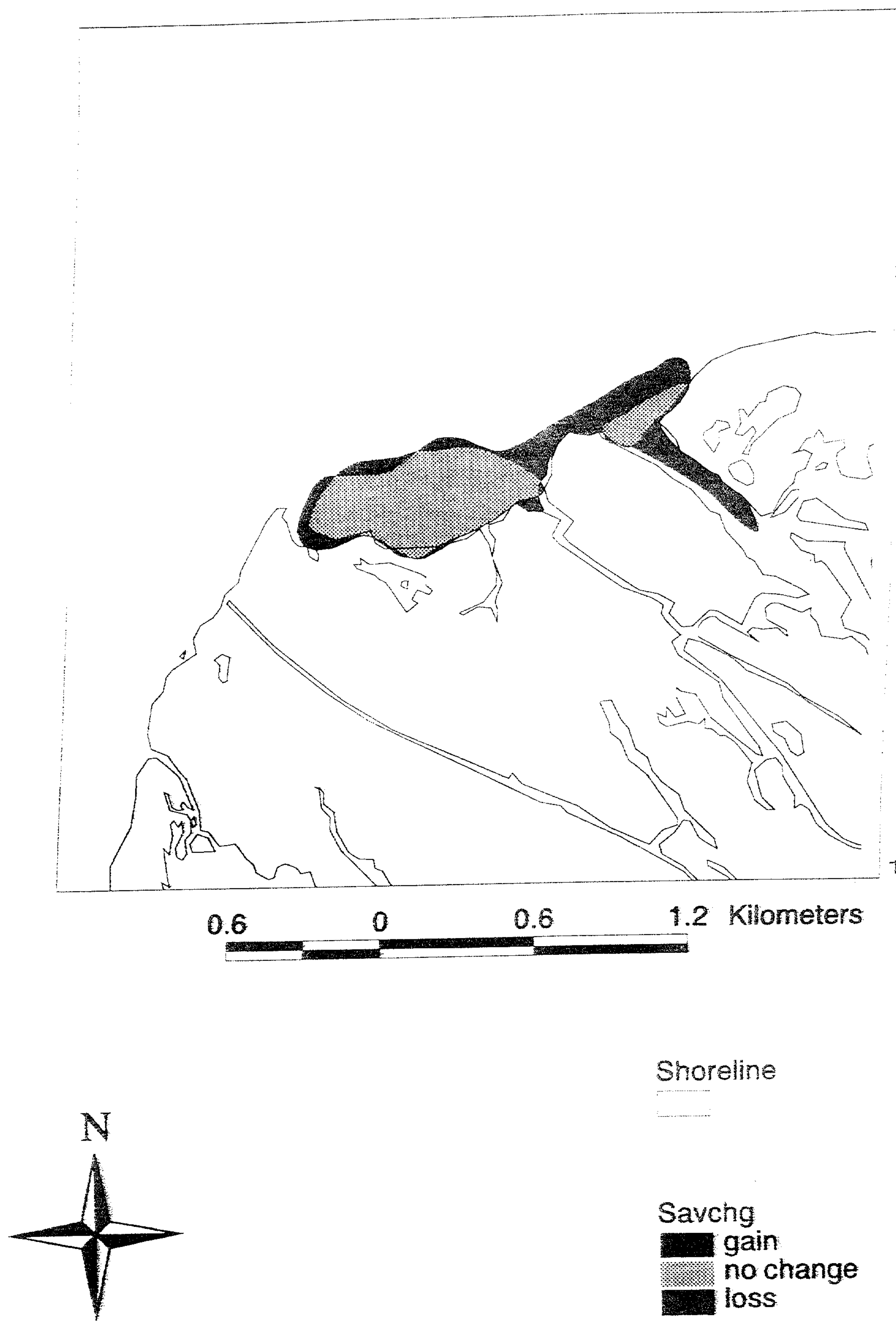


Fig 34

SAV Change in Fog Point Cove 1992-1993

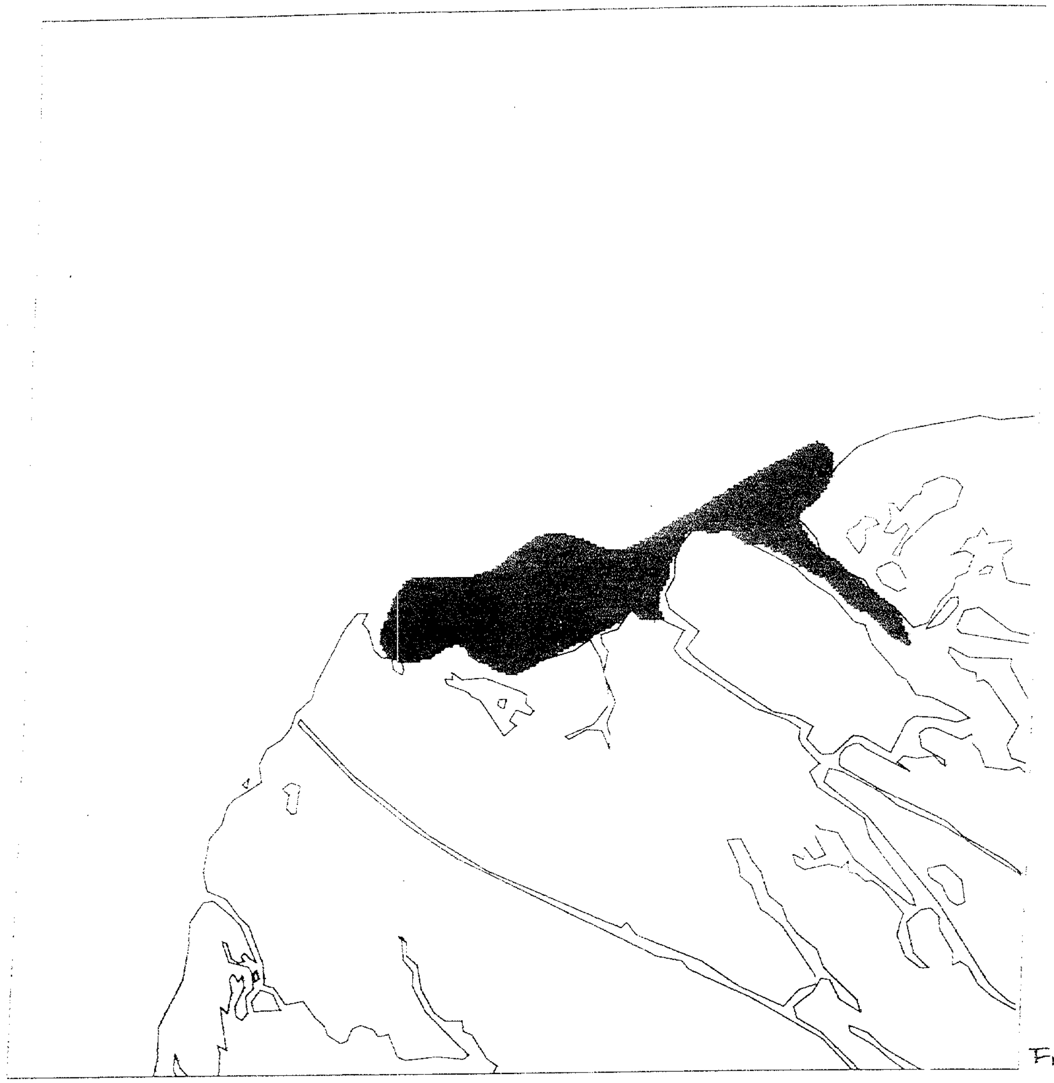
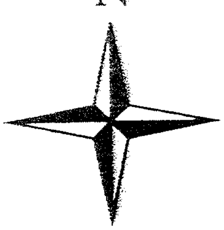


Fig 35

0.6 0 0.6 1.2 Kilometers

current shoreline
shoreline

N



SAV change 1992 to 1993

loss
no change
gain

SAV Change in Fog Point Cove 1993-1994

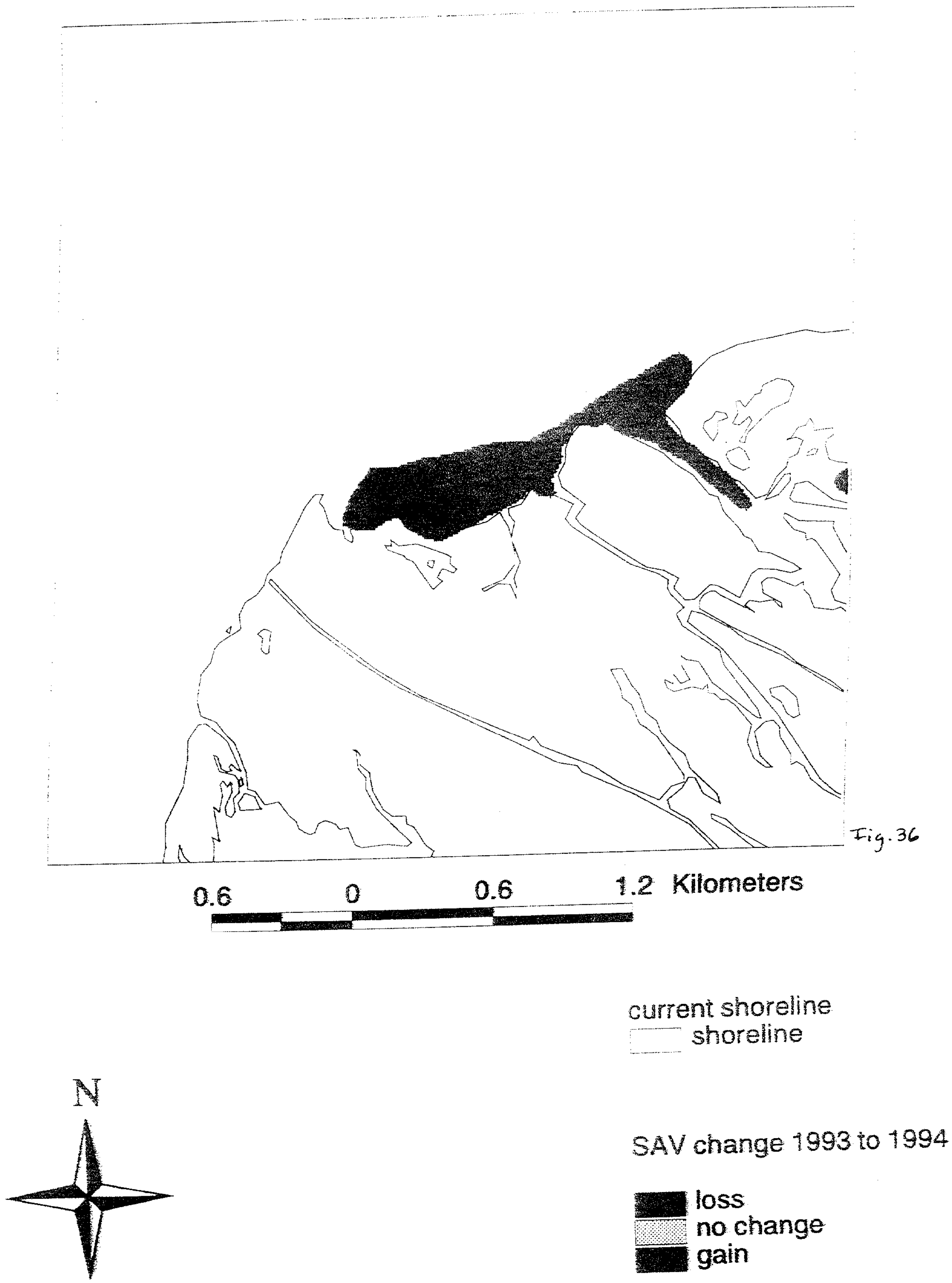


Fig. 36

SAV Change in Fog Point Cove 1994-1995

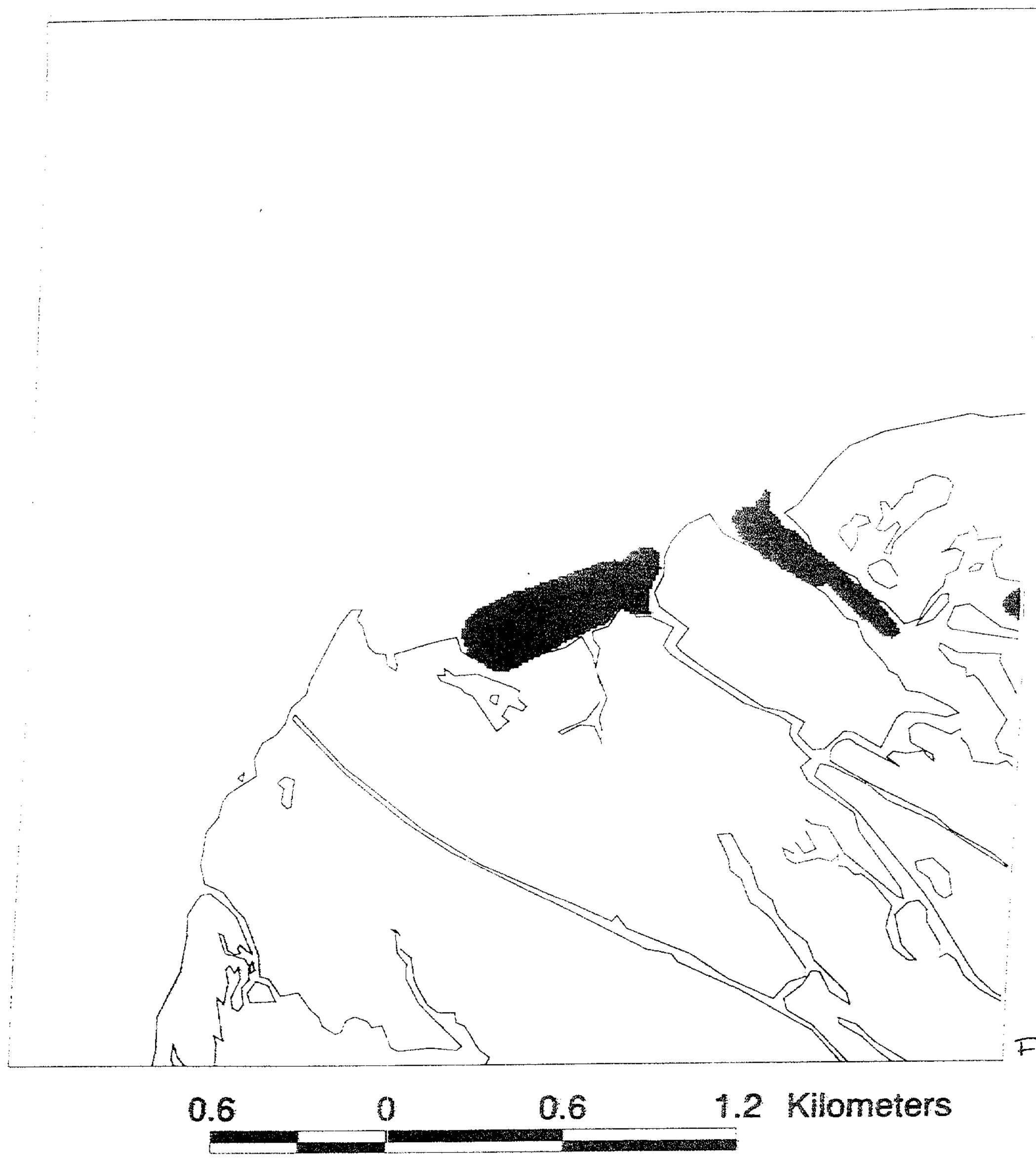
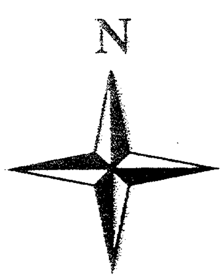


Fig. 37

current shoreline
shoreline

SAV change 1994 to 1995

loss
no change
gain



SAV Change in Fog Point Cove 1995-1996

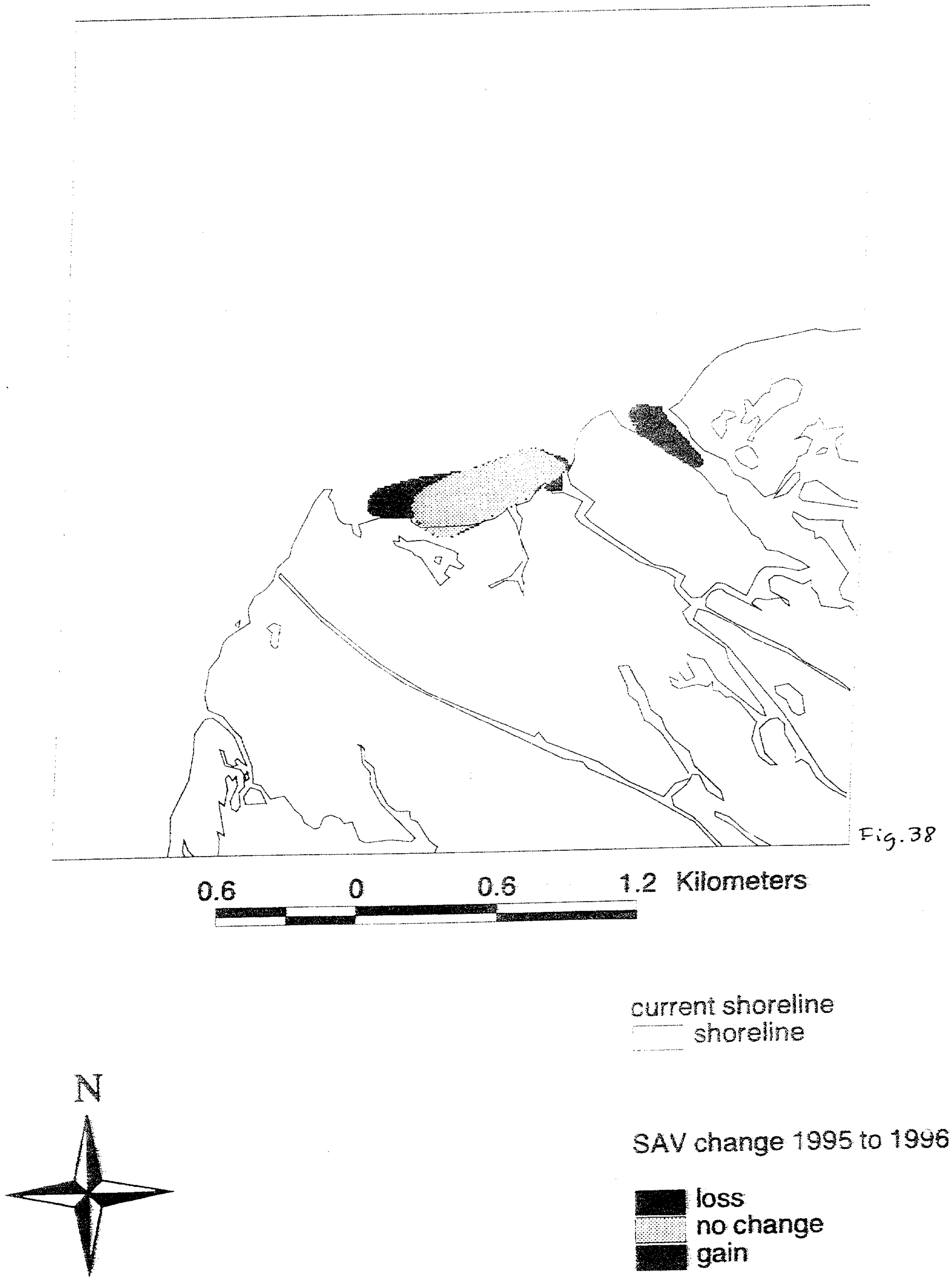


Fig. 38

SAV Changes in Fog Point Cove 1996-1997

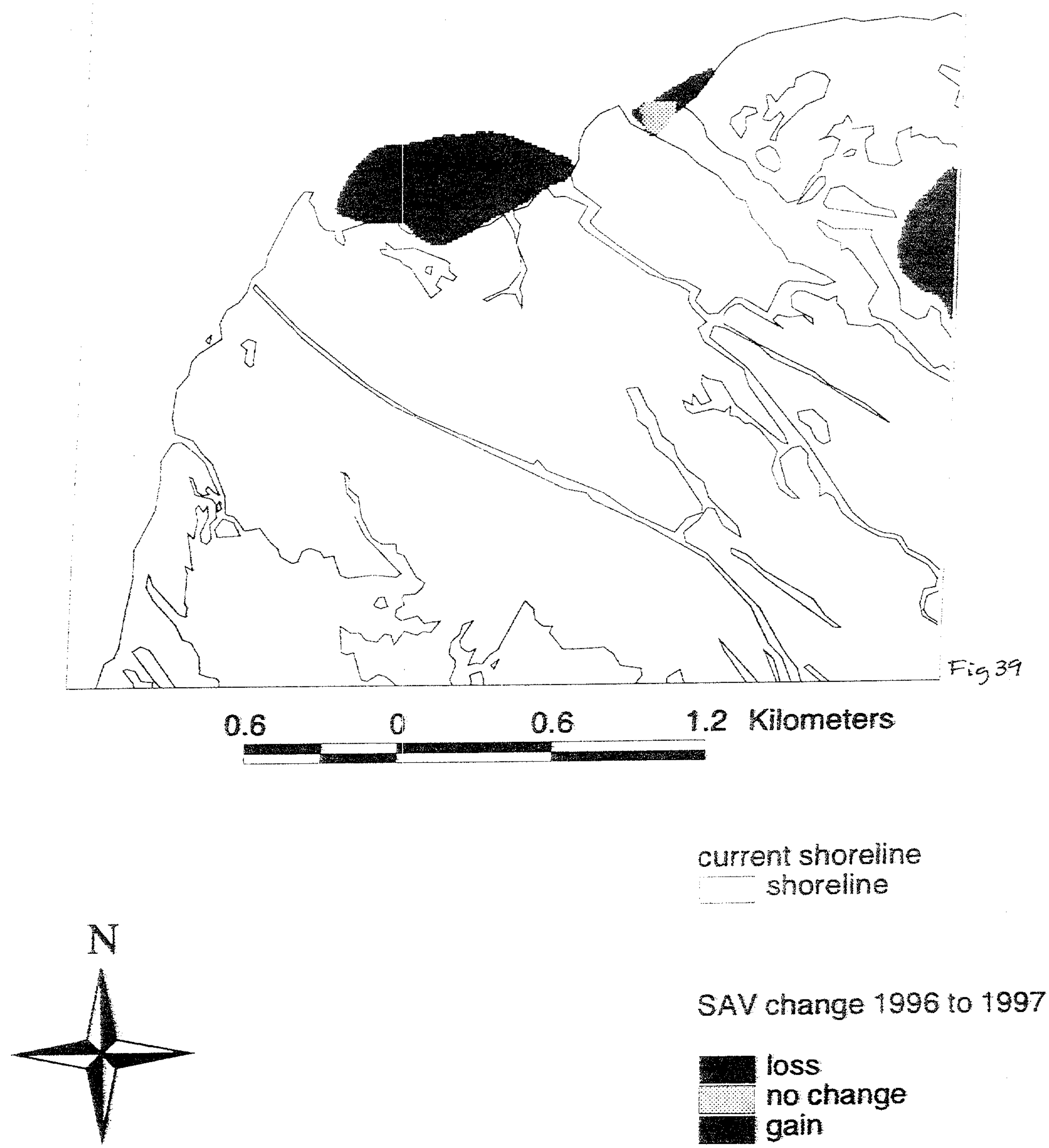


Fig 39

SAV Changes in Back Cove from 1992 to 1997

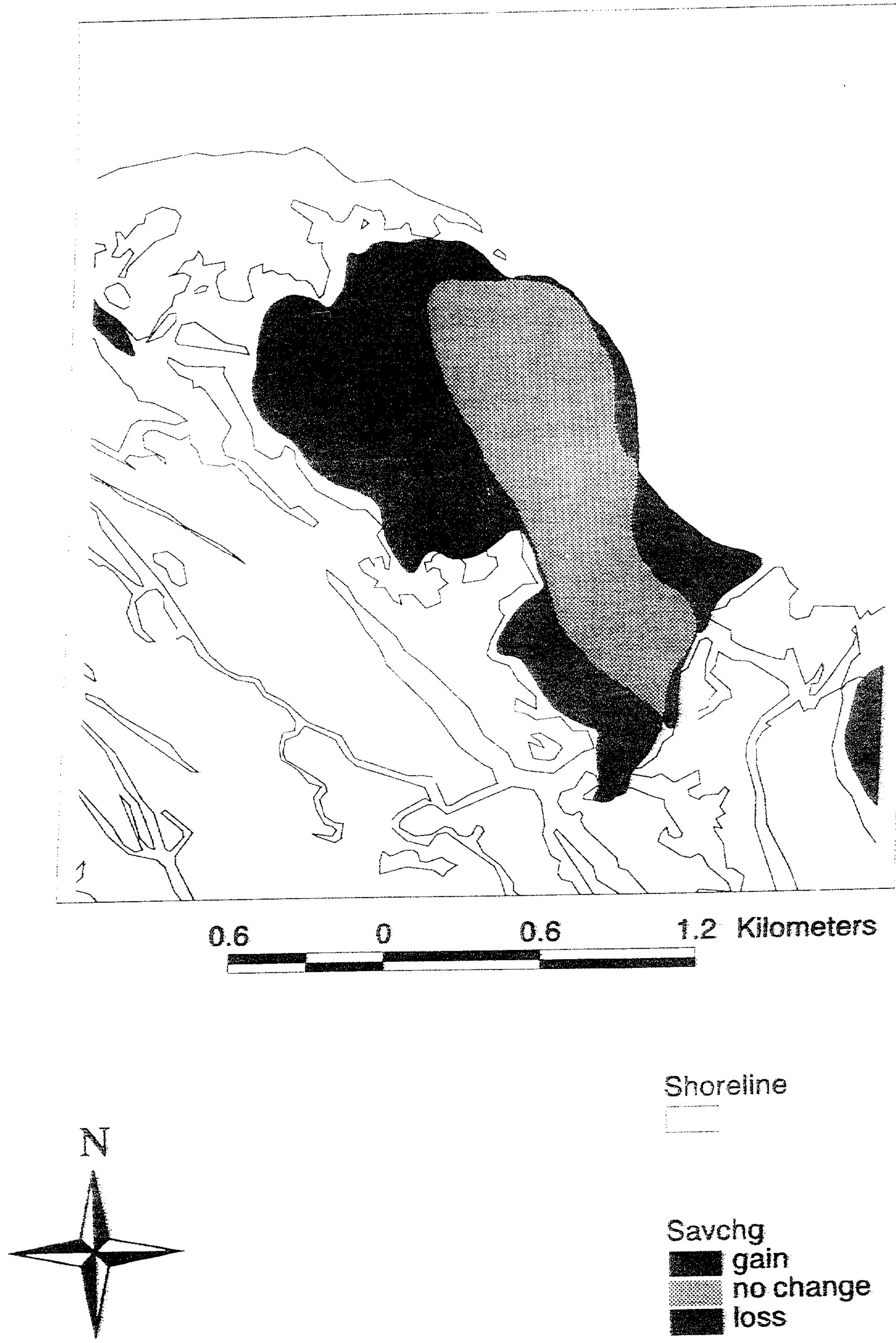


Fig 40

SAV Changes in Back Cove 1992-1993

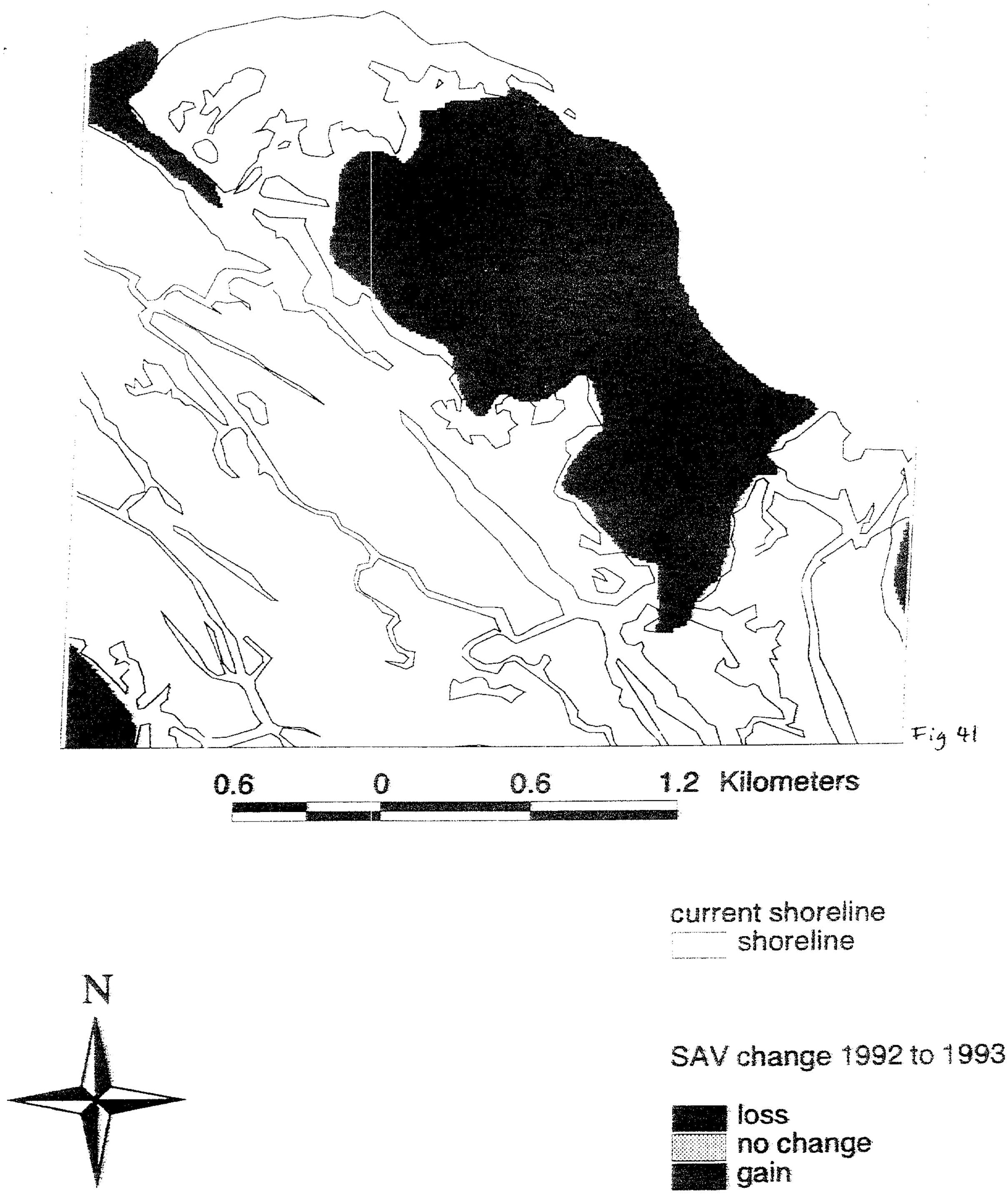


Fig 41

SAV Changes in Back Cove 1993-1994

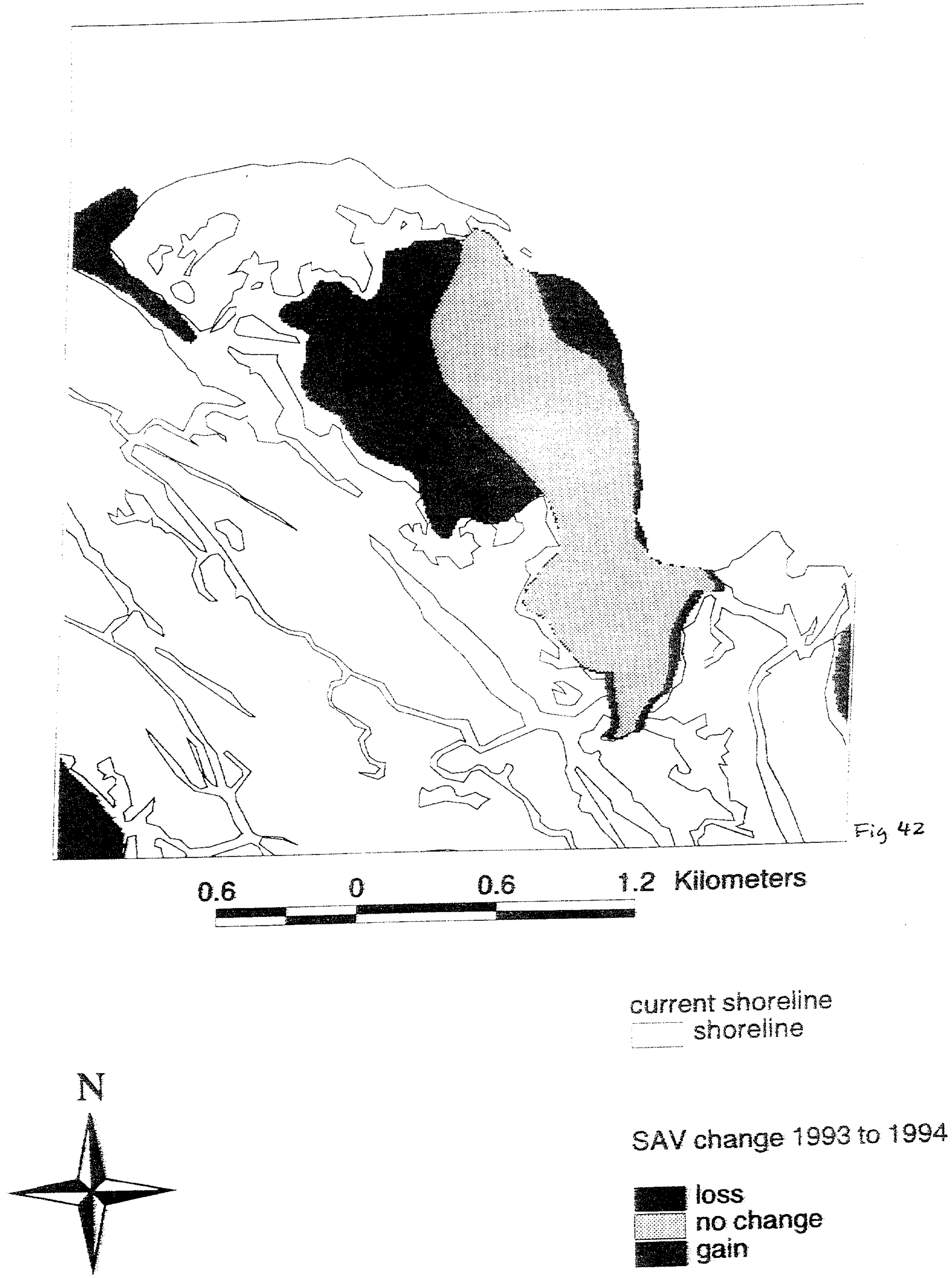


Fig 42

SAV Changes in Back Cove 1994-1995

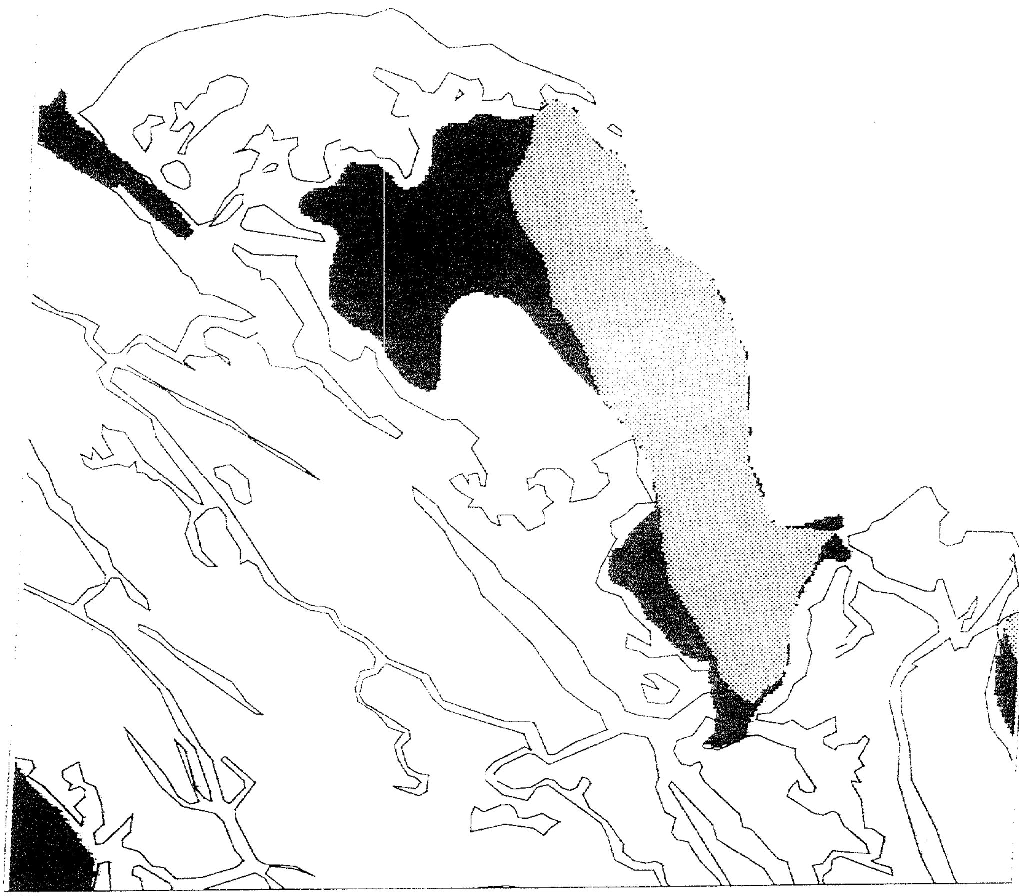


Fig 43

0.6 0 0.6 1.2 Kilometers

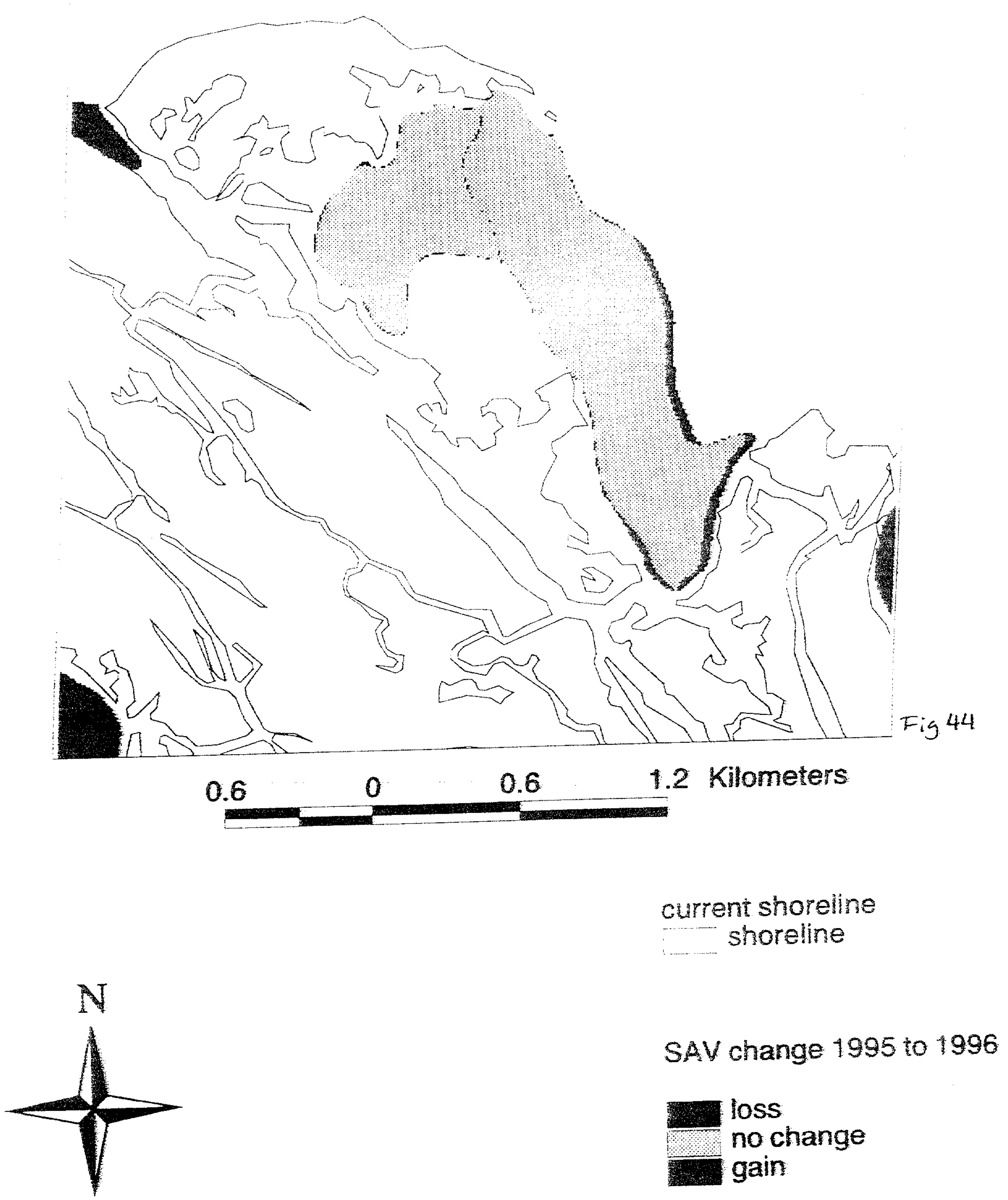
current shoreline
shoreline

N

SAV change 1994 to 1995

loss
no change
gain

SAV Changes in Back Cove 1995-1996



SAV Changes in Back Cove 1996-1997

Fig. 45

current shoreline
shoreline

N

SAV change 1996 to 1997

loss
no change
gain

able to come back in areas that have been unvegetated for many years (possibly from their seed bank).

Although it is tempting to associate the recovery of the seagrasses in Back Cove area in 1999 with the low run off (drought) in the early growing season, this explanation does not apply to the recovery of the seagrasses in Back Cove 1996 – the wettest year on record. Therefore, the changes in seagrass cover are probably due to the natural fluctuations of the species that colonizes this area.

Terrapin Sand Cove

The five years between 1992 and 1997 represented the period during which most of the submersed vegetation within Terrapin Sand Cove disappeared (Fig. 46) along the deeper edges as well as nearshore but preliminary data shows the almost complete recovery (except the northeast portion) of the vegetation by 1999.

Between 1992 and 1993, the entire seagrass bed in Terrapin Sand Cove showed a decline in coverage, except for a northern portion of the bed (Fig. 47). The next year, the vegetation nearshore recovered (Fig. 48). While between 1994 and 1995 only a relatively small portion of this recovered area showed another decline, the seagrass bed expanded southward (Fig. 49). The next year showed the expansion of the seagrass bed into the northern portion of the cove but also the decline of the portion that had recovered in 1994 (Fig. 50). Then, between 1996 and 1997, all vegetation disappeared in this cove once again (Fig. 51) only to recover by 1999 (preliminary data).

SAV Changes in Terrapin Sand Cove from 1992 to 1997

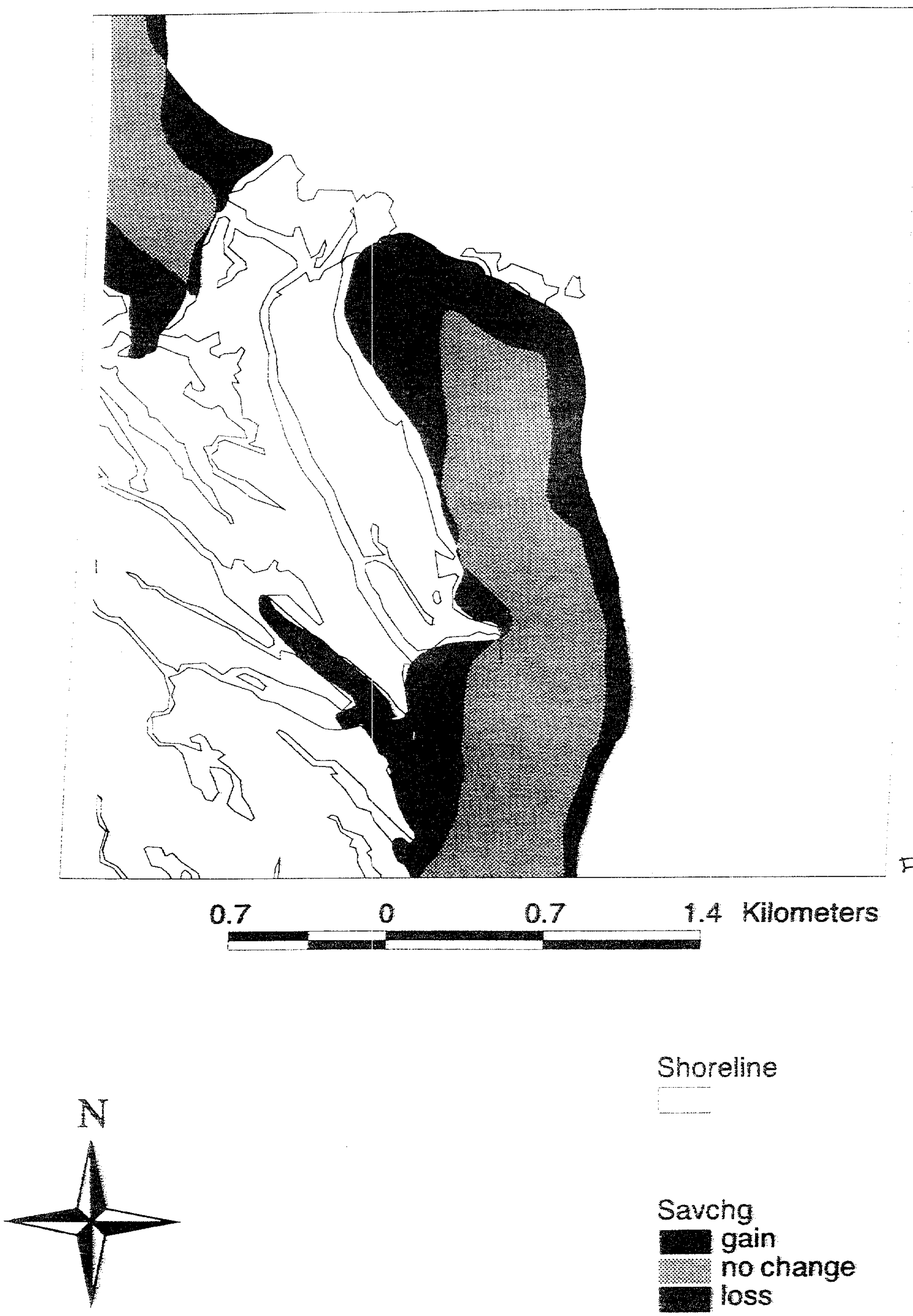


Fig 46

SAV Changes in Terrapin Sand Cove 1992-1993

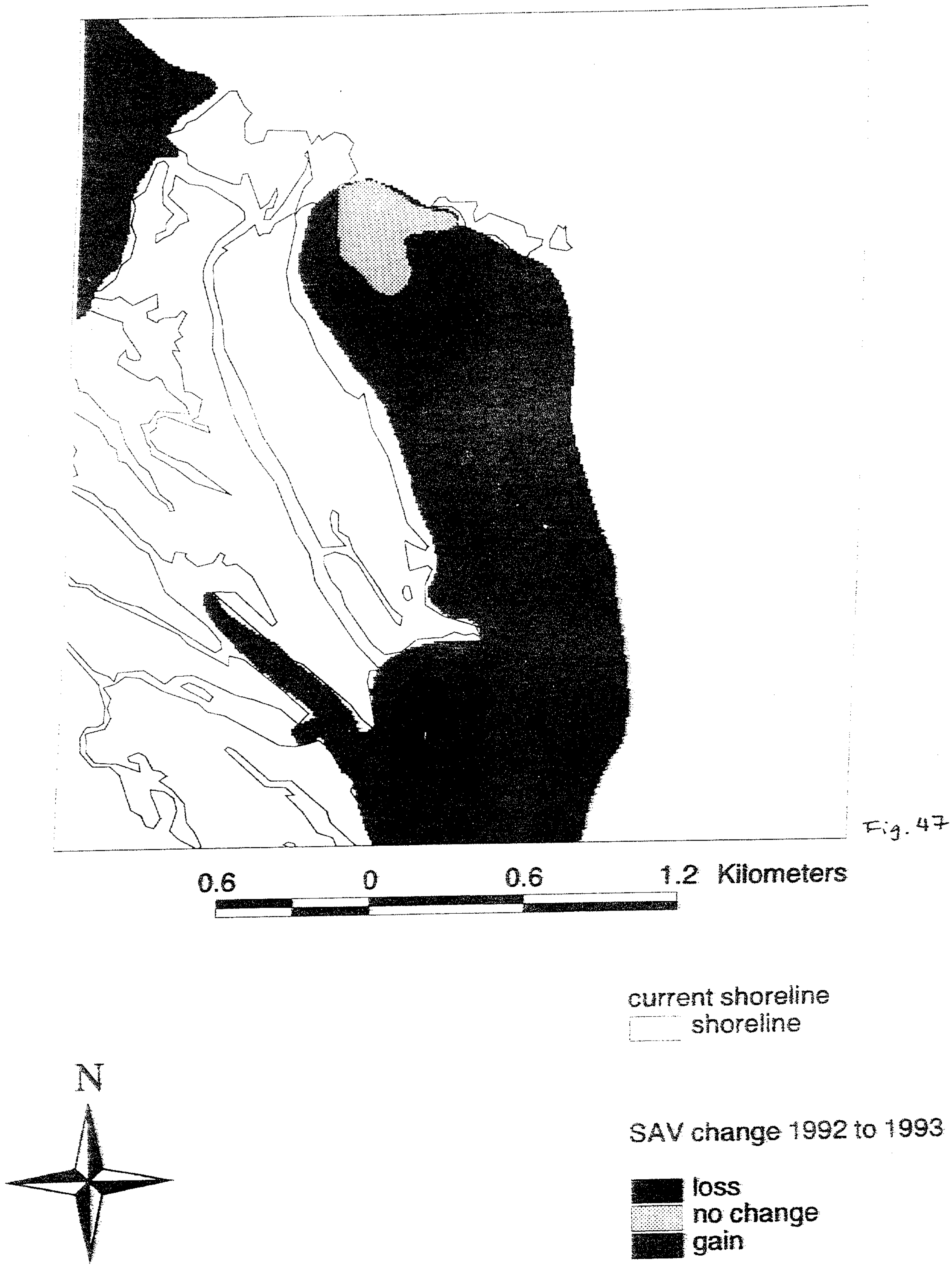


Fig. 47

SAV Changes in Terrapin Sand Cove 1993-1994

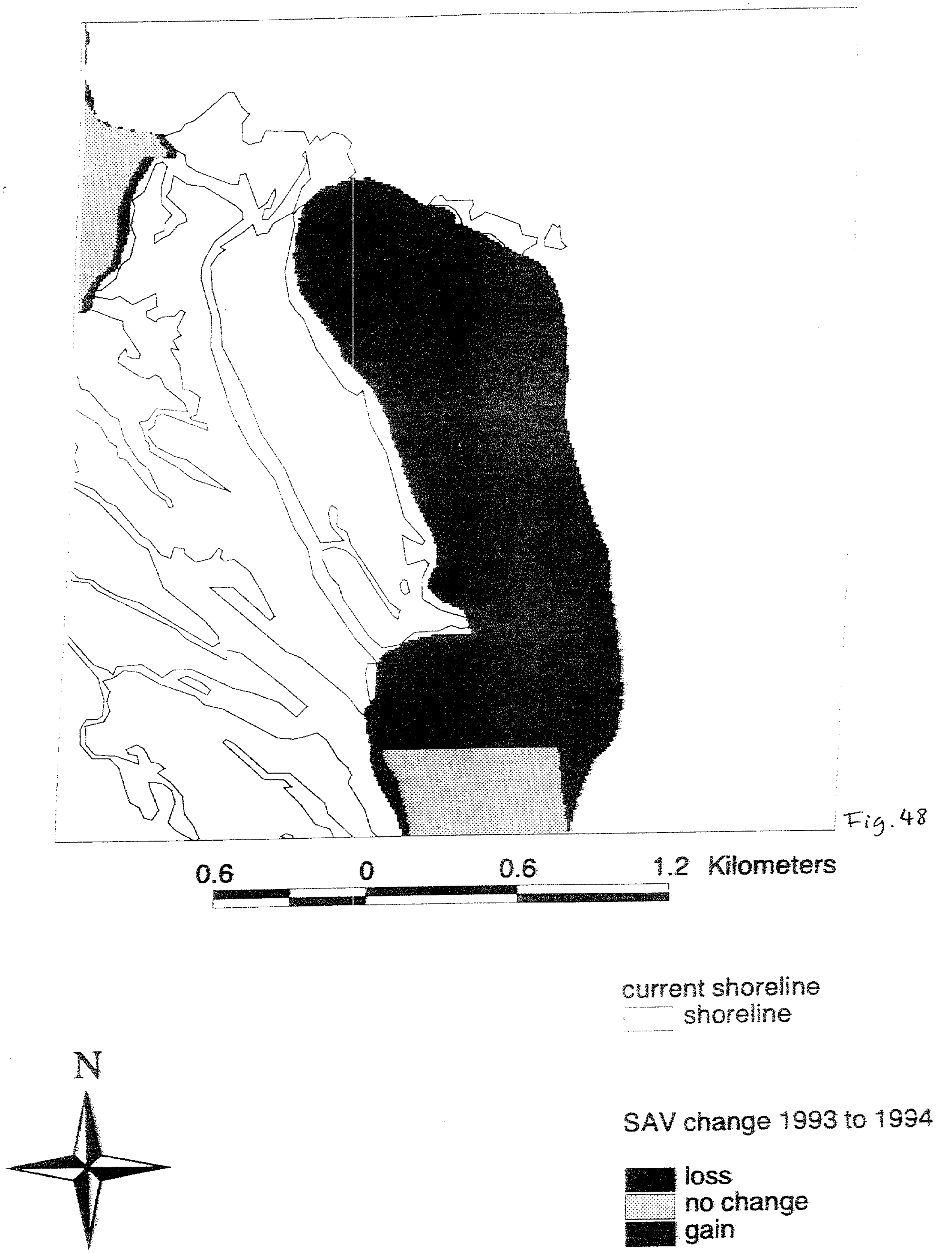


Fig. 48

SAV Changes in Terrapin Sand Cove 1994-1995

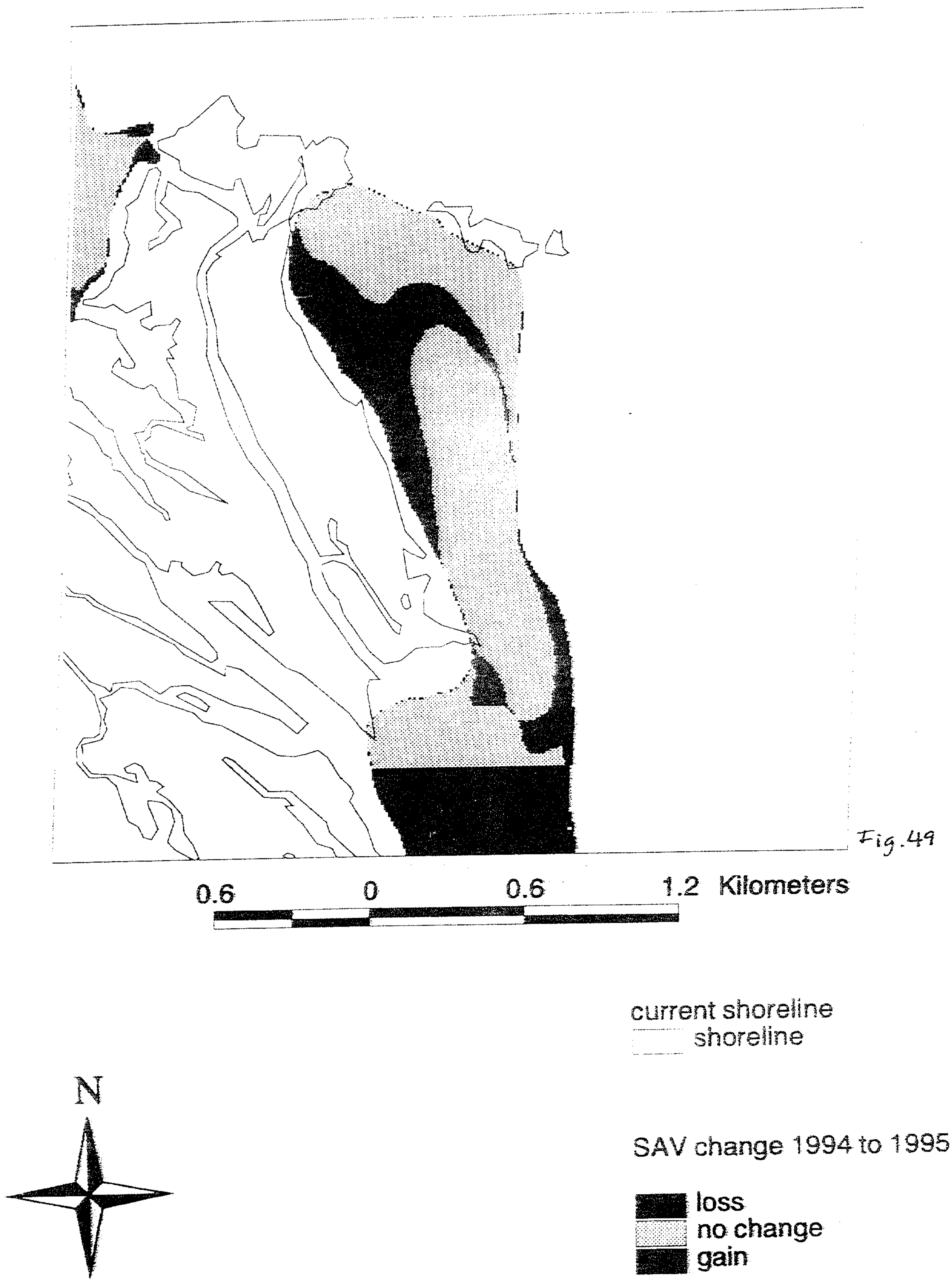
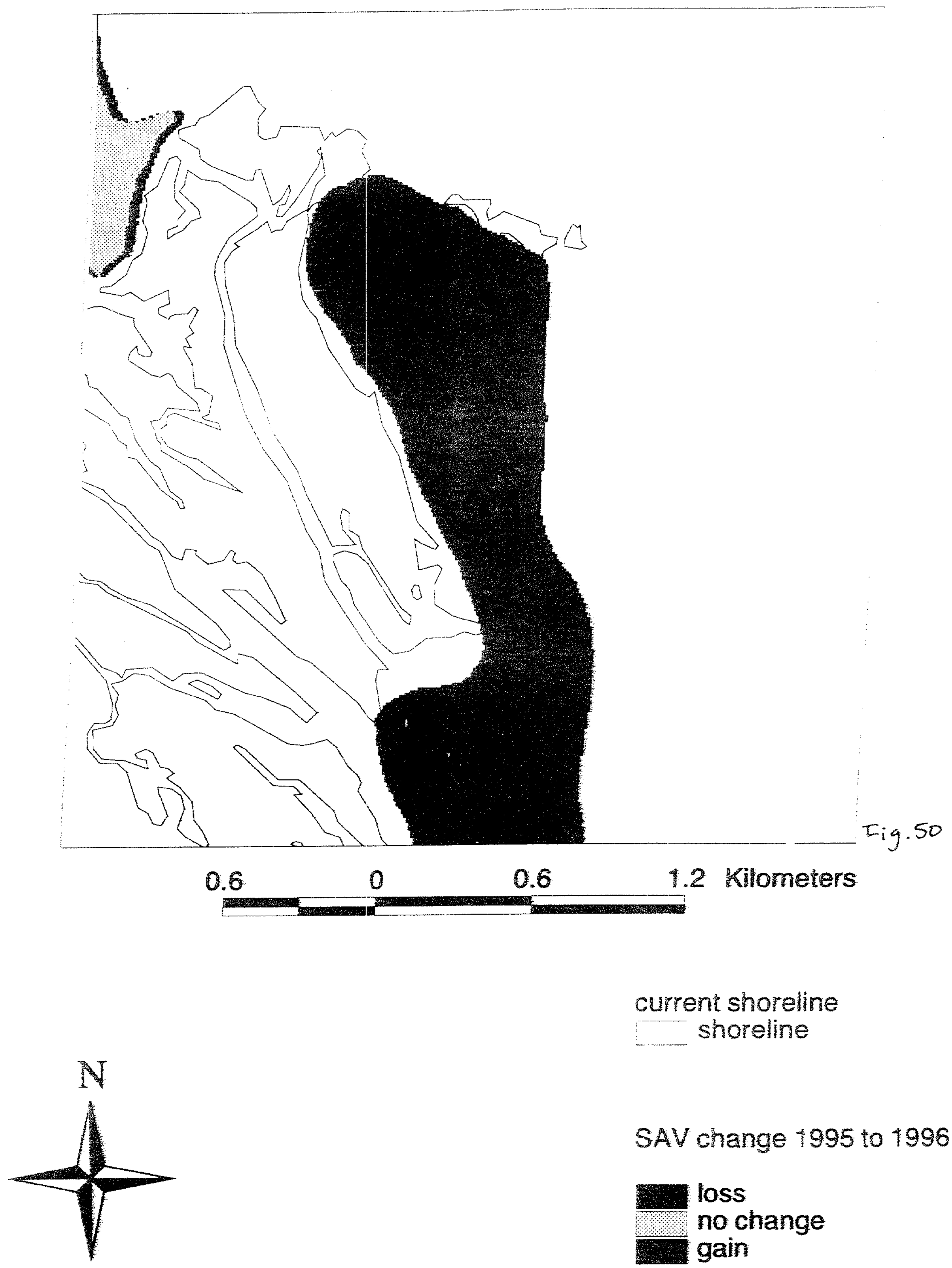


Fig. 49

SAV Changes in Terrapin Sand Cove 1995-1996



SAV Changes in Terrapin Sand Cove 1996-1997

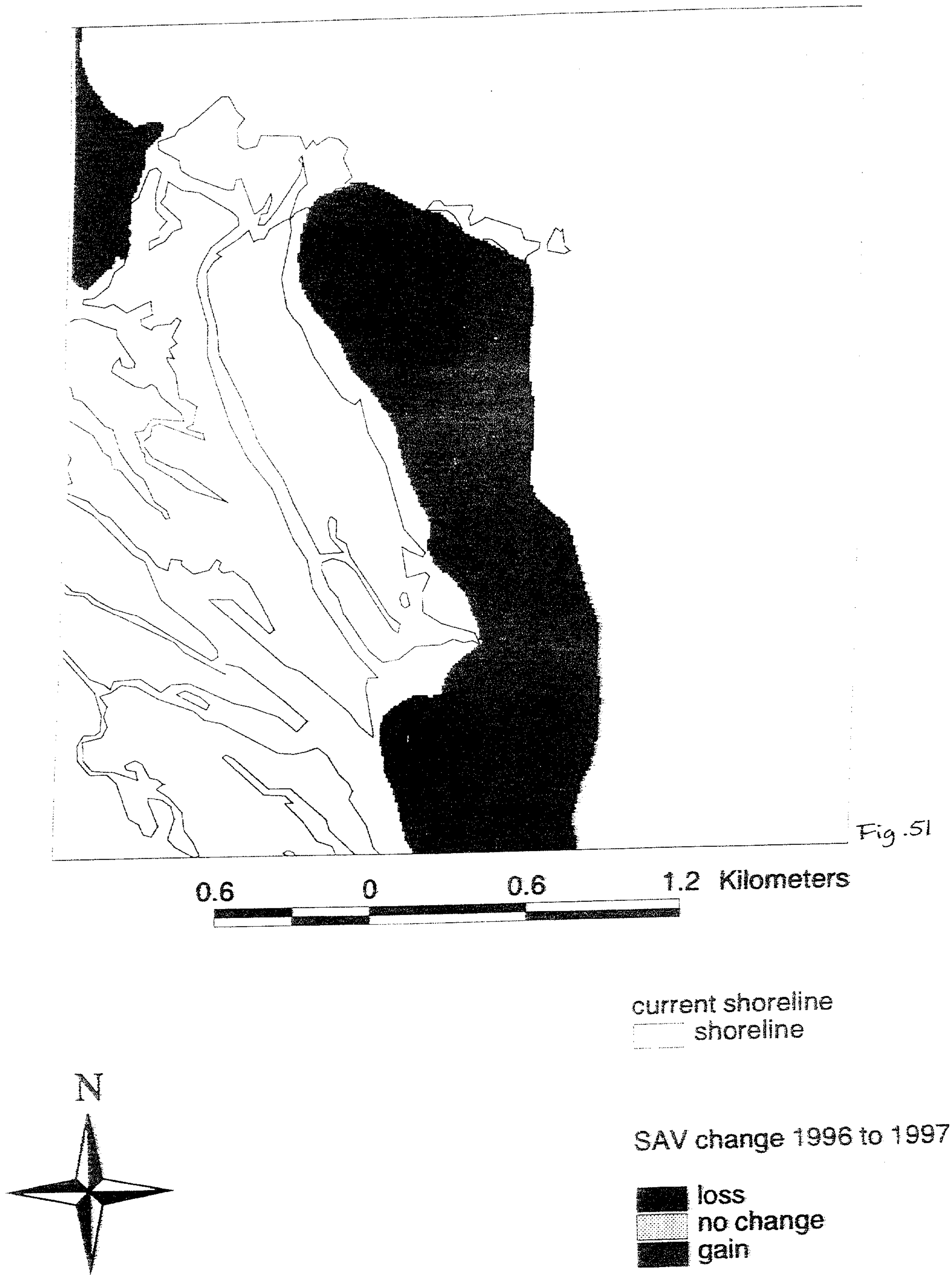


Fig. 51

Suitability of the waters of Smith Island for seagrass growth

Introduction

The Chesapeake Bay Program has established minimum SAV habitat requirements that need to be met for the survival of this submersed vegetation. These habitat requirements vary according to the different salinity zones within Chesapeake Bay. For the successful colonization of seagrass in the Smith Island area the following criteria need to be met: light attenuation coefficients (K_d) below 1.5 m^{-1}, total suspended solid (TSS) concentration below 15 mg l^{-1}, chlorophyll a concentration below 15 µg l^{-1}, dissolved inorganic nitrogen (DIN) concentration below 0.15 mg l^{-1} and dissolved inorganic phosphorous (DIP) concentrations below 0.02 mg l^{-1} (Batiuk et al. 1992).

Light

The area between Smith and Tangier Islands has the largest continuous SAV bed in the Chesapeake Bay and, therefore, it is believed that the Smith Island area is very suitable for seagrass growth. Unfortunately, the distribution of seagrass in this area has been declining since 1992. This decline is occurring at a faster rate in Tangier Sound than in the rest of Chesapeake Bay. The concentration of nutrients found in the waters around Smith Island are not increasing significantly but the depth of light penetration is decreasing. This is believed to be due to the increase in sediment input from tributaries into Tangier Sound. As marshes and farmland erode, the soil is transported into streams and is ultimately carried into the Chesapeake Bay. When these relatively fine sediments are introduced into the water column, they tend to remain in suspension for quite long periods of time. Light impacting these suspended particles is then scattered and attenuation in the water column increases. Since seagrass colonize the bottom (roots in the sediment), the amount of light that reaches this vegetation depends on the amount of particles in the water. Therefore, the increase in suspended sediment particles may be leading to the loss of seagrass in the Tangier Sound region.

One may argue that marshes are eroding in all areas of the Chesapeake Bay and not just in the Tangier Sound area. So, if an increase in suspended sediment particles originating from marshes is suppose to be the cause for the loss of seagrass in the Tangier Sound area, why are seagrass not disappearing at the same rate in other areas of Chesapeake Bay? The tidal range may play a role in this process.

Tides and seagrass in the Smith Island area

As seagrass live on the bottom, light needs to travel through the water column before the plants can utilize it for photosynthesis. At high tide, the light needs to travel through a longer distance/depth than at low tide before it reaches the surface of the seagrass leaves. Therefore, tides can impact the distribution of seagrass. In areas where the tidal range is high, seagrass can not grow as deep as in areas with lower tidal ranges. As a result, in areas with high tidal range, seagrass are more susceptible to poor water quality (faster light attenuation through the water column) than in areas where the tidal level is small (Koch and Beer 1996).

In Chesapeake Bay, the tidal ranges tend to be higher in the east than in the west (Fig 52). As Smith Island is located on the eastern side of Chesapeake Bay, it is in an area where seagrass are more susceptible to degradation of the water column than in other

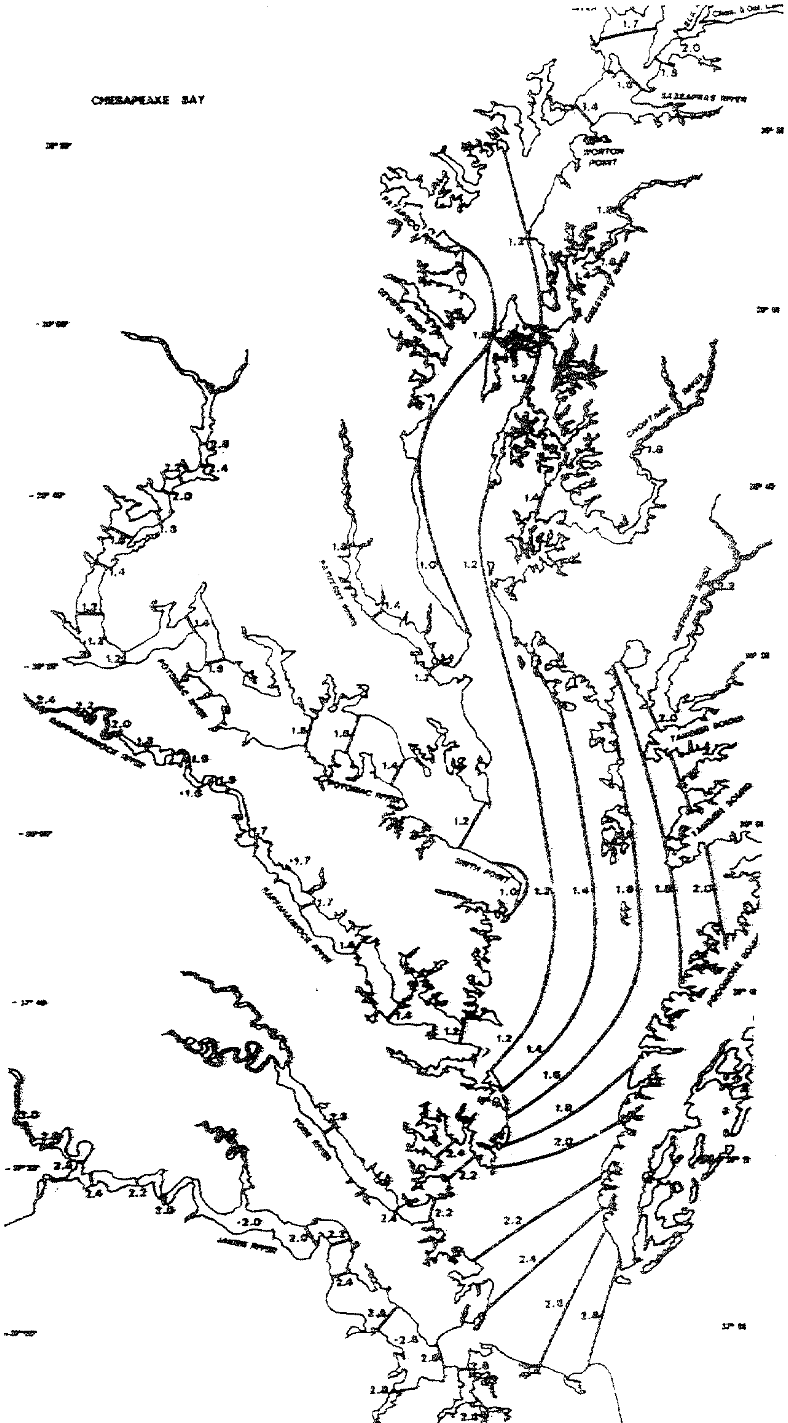


Figure 52. Geographycal distribution of the tidal range (in feet) in Chesapeake Bay. Note that Smith Island is located on the eastern side of the Bay, where the tidal range is relatively high. This makes the seagrasses in this area more vulnerable to eutrophication.

areas of the bay. This may explain why the loss of seagrass is more accentuated in the Tangier Sound/Smith Island region than in other parts of the Bay. Another reason that needs to be taken into consideration is the rate of degradation of the marshes in different areas of Chesapeake Bay.

Depth

As light is essential for the survival of seagrasses, any parameter that affects light availability has the potential to affect the health of the submersed vegetation. Tides were discussed above as a parameter that alters light availability by changing the depth of the water column. The depth (from mean tidal level) of a certain area is obviously also important for the distribution of seagrasses. If the area is too deep, not enough light will reach the plants and therefore, the vegetation will not be able to become established.

In the past, when the waters quality of Chesapeake Bay was better, more light reached the bottom and seagrasses were found to depths of 5 meters (Orth, personal communication). In 1999, the minimum habitat requirements established by the Chesapeake Bay Program to predict the growth and survival of seagrasses were not met at a 2 meters depth, were only met 13% of the time at a 1 meter depth and 43 and 64% of the time at depths of 0.5 and 0.25 meters, respectively (Bergstrom, personal communication). This suggests that, presently, 1 meter depth (approximately 3 feet) is the maximum depth at which seagrasses can be expected to be found. Therefore, areas deeper than 1 meter are not suitable for seagrasses. This may change in the future if water quality improves.

The 1 meter depth contour around the Smith Island area is shown in Fig. 53. Potentially, all the areas in blue could be colonized by seagrasses. Note that the shallow seagrass habitats (<1 m) in the Tylerton area (Fig. 54) are indeed colonized by seagrasses, except the northwest portion of the town, where boating activity is intense. The Sheep Pen Gut area is also shallow enough (Fig. 55) to support seagrass growth but is presently unvegetated. The cause for this is unknown. The pattern of vegetation in the Swan area closely follows the 1 meter contour shown in Fig. 56 but note that the Big Thoroughfare area is suitable for seagrass growth but the vegetation no longer occurs there, possibly due to the deposition of sediment on top of the vegetation as a result of the breaching of a portion of the island. The northern coves of Smith Island (Fog Point, Back and Terrapin Sound Coves) certainly have depths shallow enough to support seagrass growth (Figs. 57, 58,59) and, consequently, the continuous fluctuations in seagrass coverage can not be justified by the depth of these areas.

Coastal erosion and its impact on seagrass in Tangier Sound

Although the above described stresses (light based on tides and depth) in the Smith Island area are of a regional magnitude, local stresses to seagrass communities and alterations to their habitats also need to be taken into consideration to determine the feasibility of seagrass in the Smith Island area.

It was mentioned above (see "Light" on page 64) that the erosion of the marshes in the Tangier Sound area is generating a very high load of particles which are delivered to the creeks and rivers and ultimately reach seagrass habitats where they reduce the light

One Meter Contour for the Smith Island Area

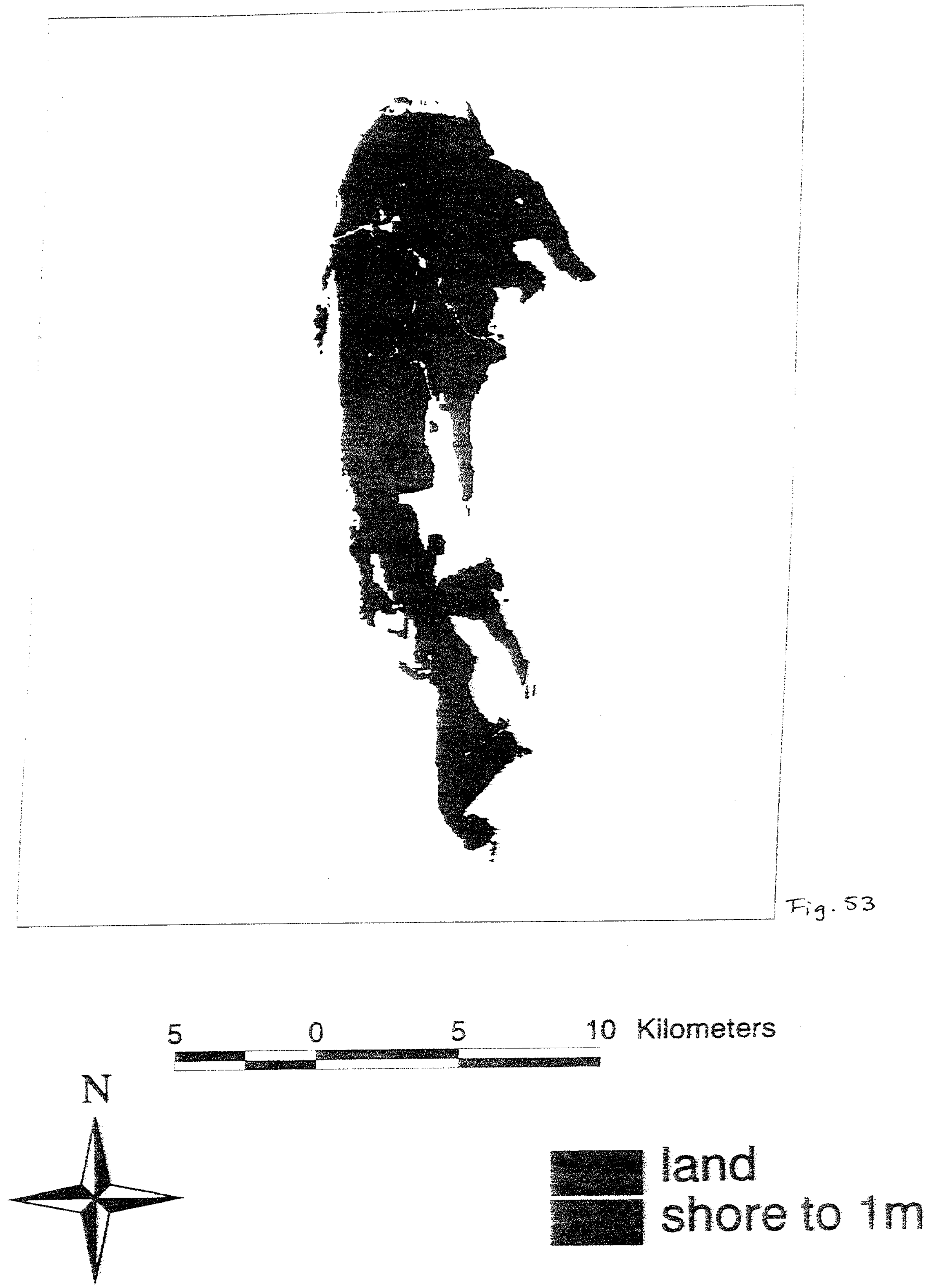


Fig. 53

Shore to One Meter Depth of Tylerton Area

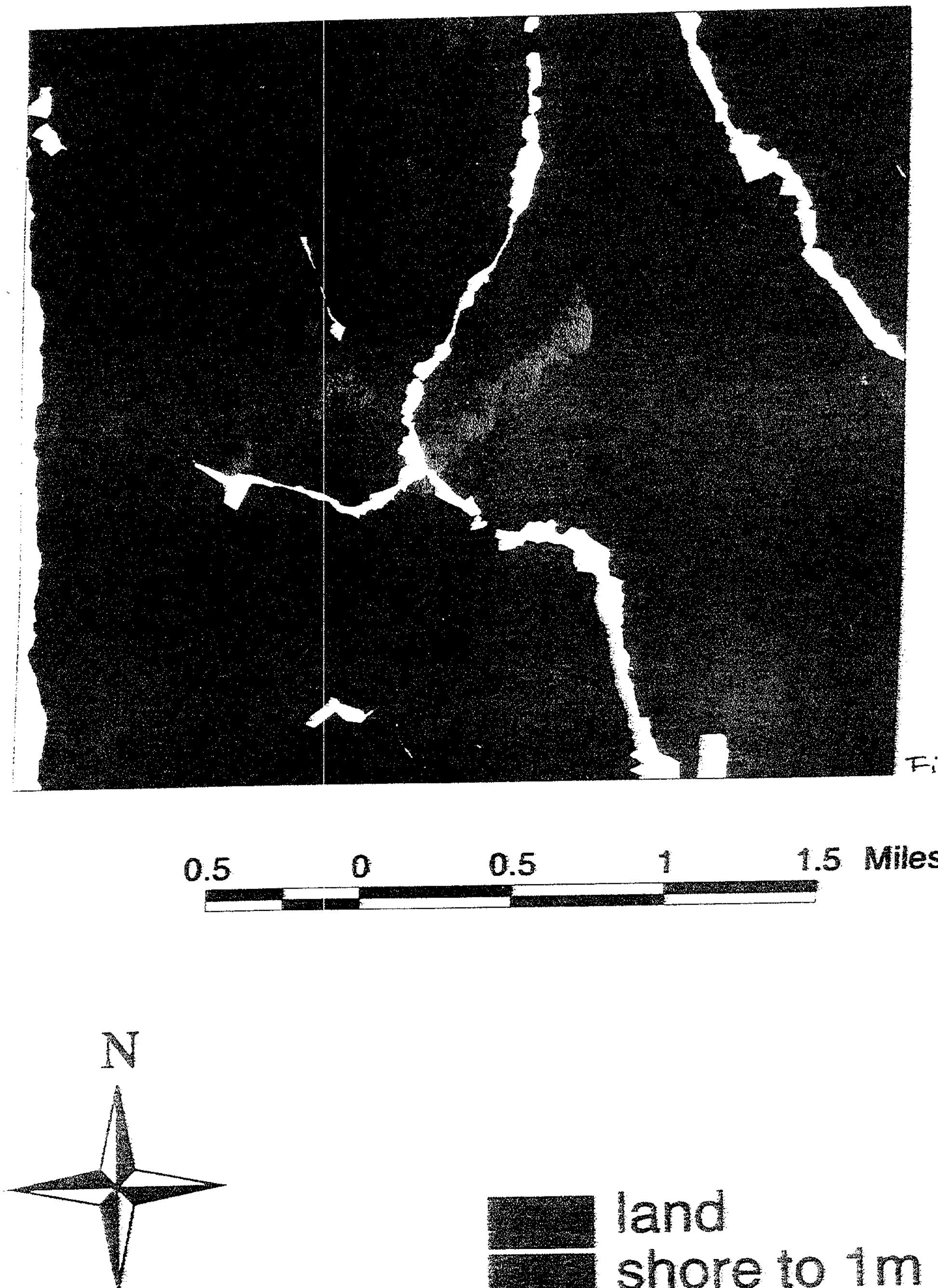
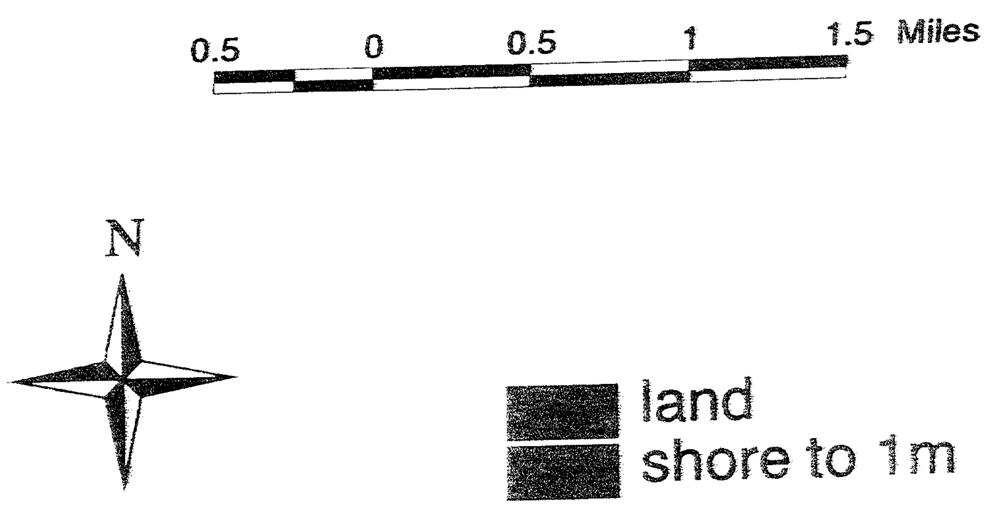


Fig. 54

Shore to One Meter Depth of Sheep Pen Gut Area

Fig. 35



Shore to One Meter Depth of Swan Island Area

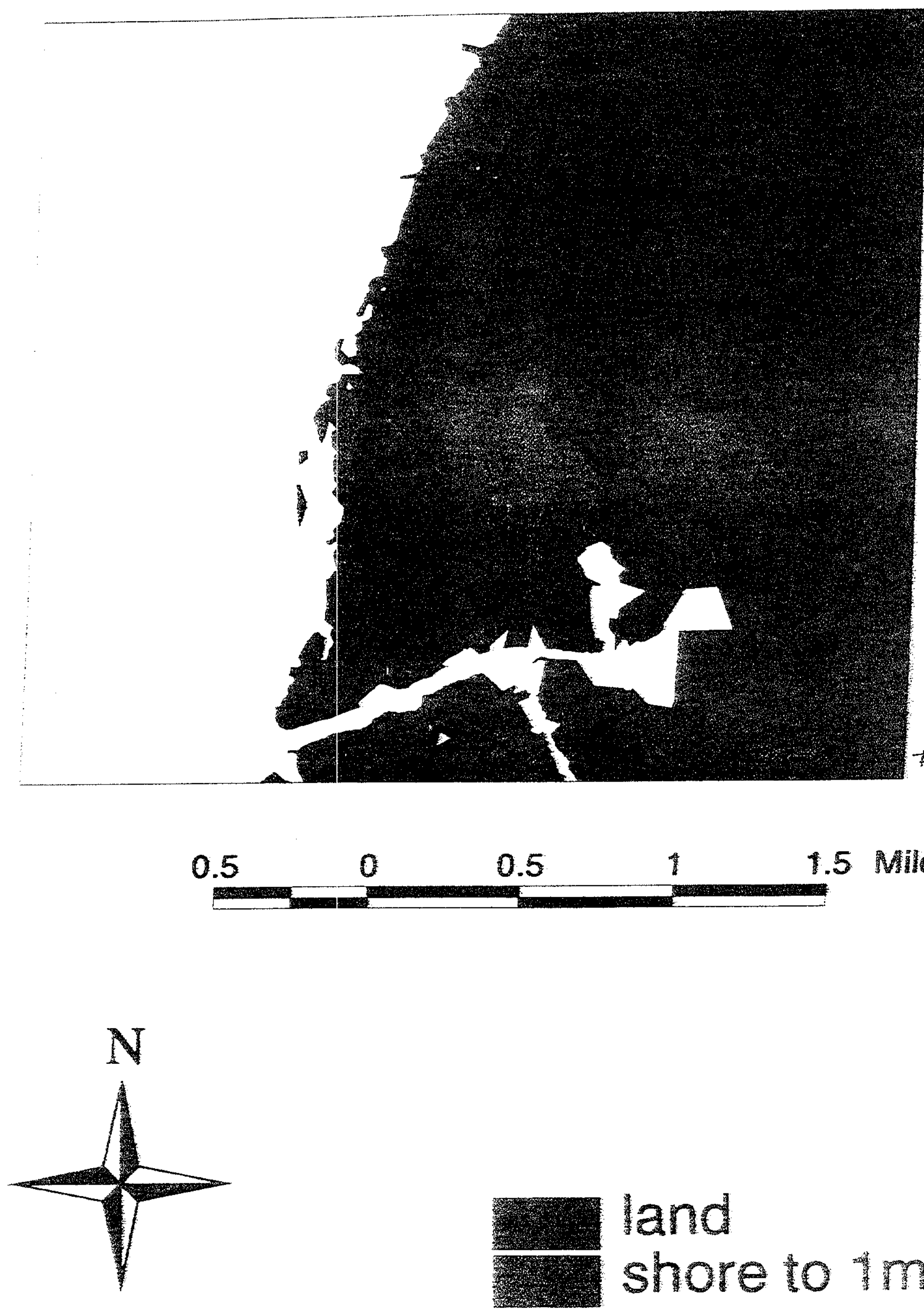


Fig. 56

Shore to One Meter Depth of Fog Point Cove

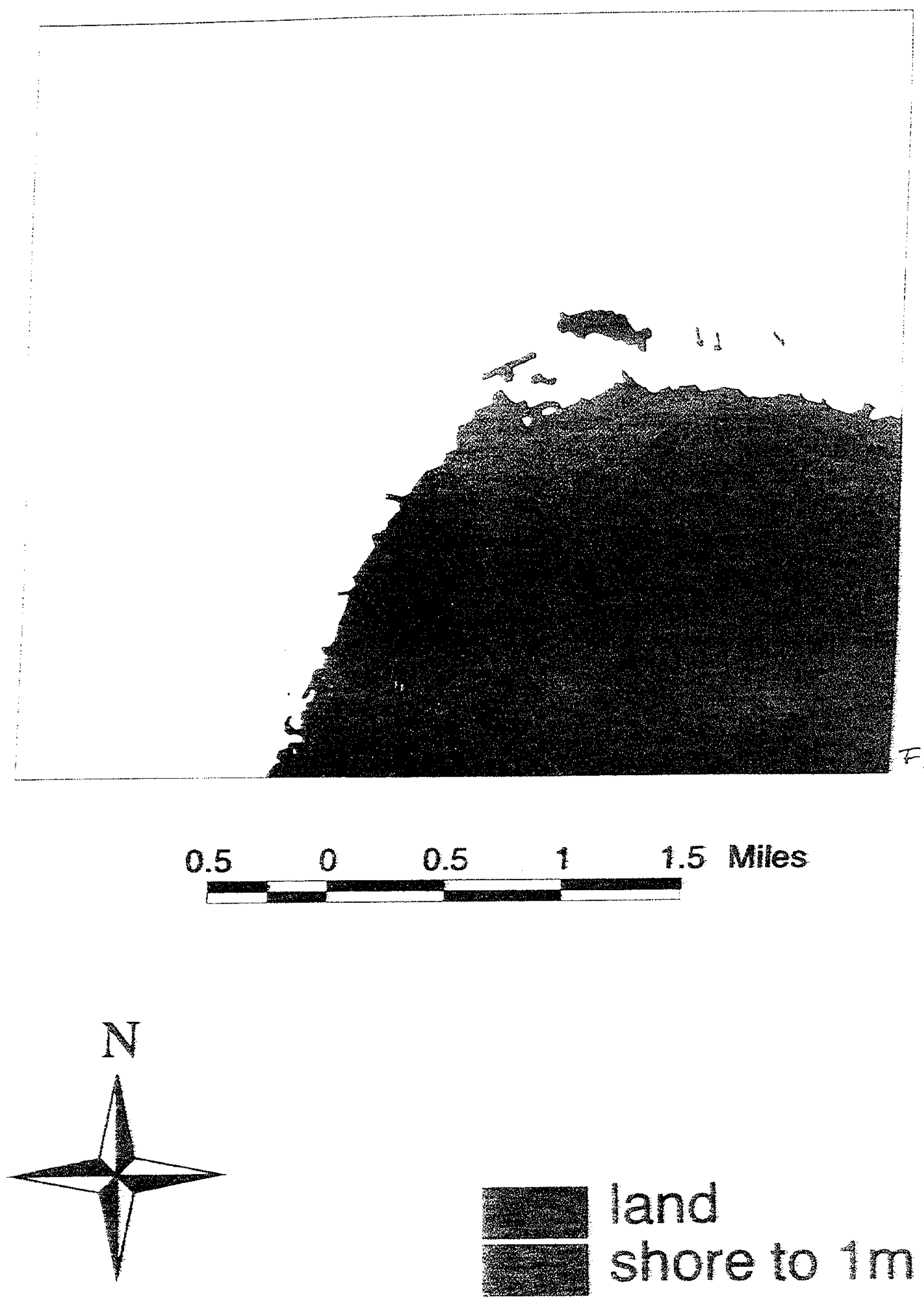


Fig. 57

Shore to One Meter Depth of Back Cove

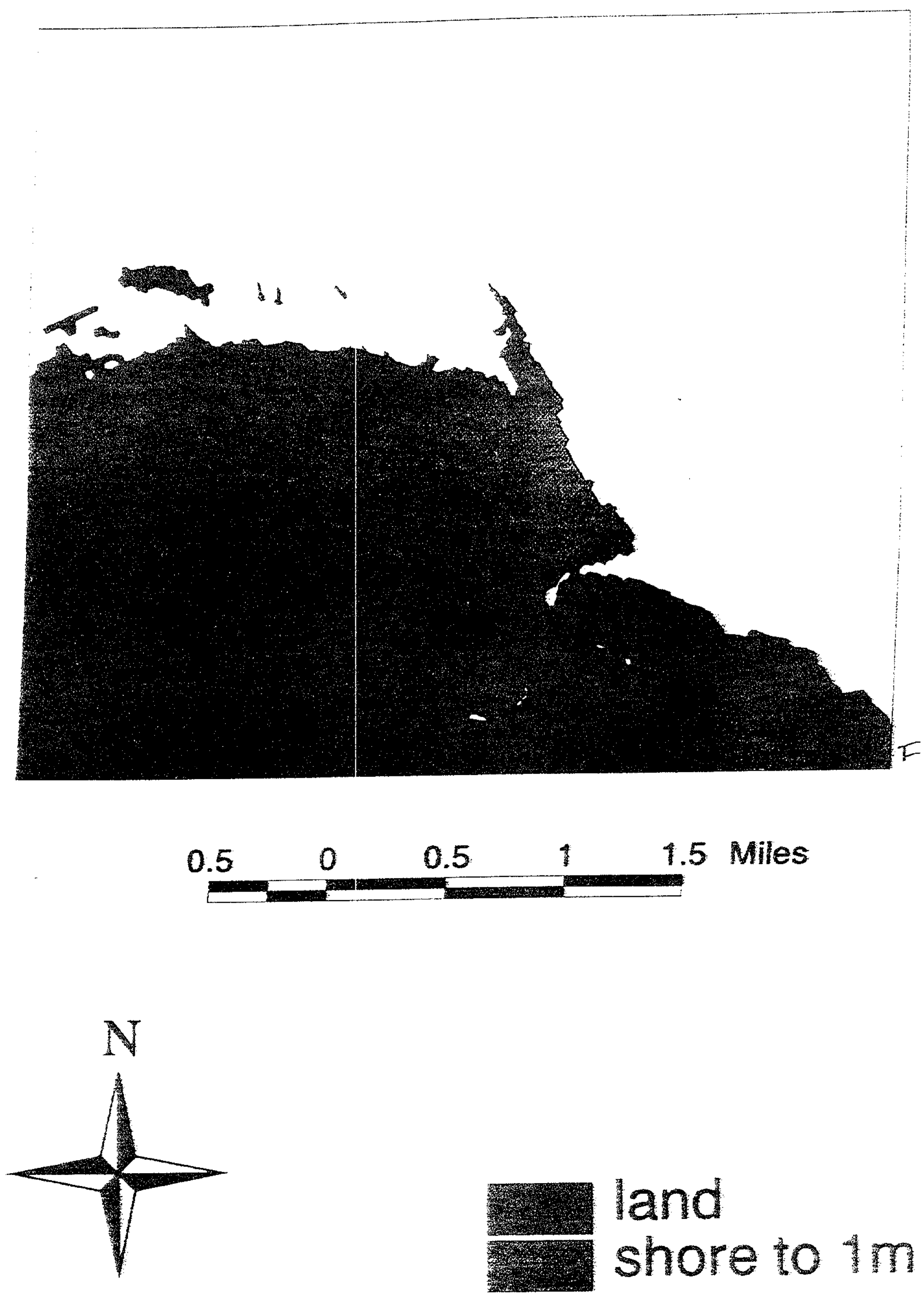


Fig. 58

Shore to One Meter Depth of Terrapin Sand Cove

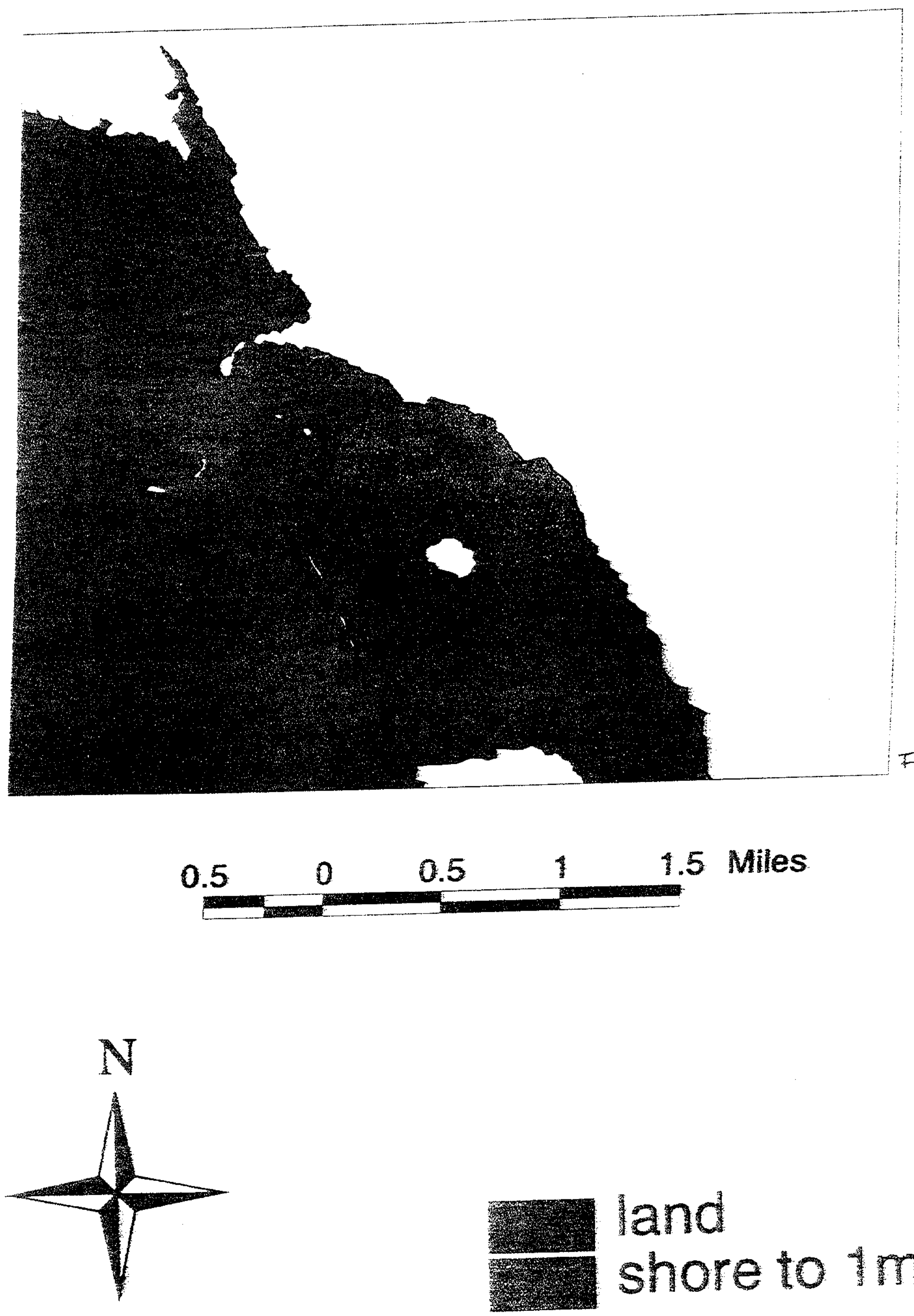


Fig. 59

levels that reach the vegetation. Marsh erosion can also be detrimental to seagrasses by changing the characteristics of the seagrass habitat.

In the Chesapeake Bay, wave-induced shore erosion in 1970 was estimated to contribute 52% of the total suspended solids in the mid bay where Tangier Sound is located (Biggs, 1970). As seagrasses tend to attenuate waves approaching the shore (Fonseca and Cahalan, 1992; Koch, 1996) and reduce current velocities (Fonseca et al., 1982; Ackerman, 1983; Carter et al. 1988; Gambi et al., 1990; Carter et al., 1991; Koch, 1996; Rybicki et al., 1997; van Keulen, 1997), they reduce coastal erosion and induce the settling of particles in suspension (Grady, 1981; Kemp et al., 1984; Ward et al., 1984; Posey et al., 1993). As a result, seagrasses tend to improve the water quality in the areas they colonize (Dennison et al. 1993; Moore et al., 1994). Unfortunately, since seagrass distribution has declined since the study by Biggs in 1970, presently, coastal erosion is expected to contribute even more to the concentrations of suspended solids in the water column.

Seagrasses do not only reduce coastal erosion but also stabilize the sediments they colonize therefore, a reduction of seagrass density or complete loss of the vegetation could result in the resuspension of sediment particles previously trapped by the plants. These resuspended particles contribute to light attenuation which can further contribute to the decline of seagrasses. The loss of the offshore seagrass beds, especially those on the western side of Smith Island, may have allowed for the presently severe erosion of the marshes that form Smith Island. The erosion of this island is most severe on the western and northern portions (Figs. 60, 61) which is coherent with the strong winter storms with winds from the northeast. The more protected areas like Tylerton (Fig. 62) and Sheep Pen Gut (Fig. 63) have shown relatively less erosion than the areas directly adjacent to Chesapeake Bay. Many of the shallow marshes in these areas adjacent to the Bay breached (Figs. 63, 64) developing new channels connecting the protected waters of Smith Island with those of Chesapeake Bay. The area northwest of Swan Island also showed severe erosion and where there used to be land, now there is a large breach (Fig. 64). In this figure, the erosion of the marshes exposed to the waves of Chesapeake Bay is also clear. In Fog Point Cove, an entire peninsula protecting the bay was lost due to erosion since 1942 (Fig. 65). The marshes within this cove also showed significant erosion. The same pattern is also observed for the other coves in the northern portion of Smith Island (Figs. 66, 67). Especially impressive is the loss of the islands protecting Terrapin Sand Cove (Fig. 67). This area certainly became more exposed to waves since the loss of the islands.

Although the loss of marshes and entire peninsulas and islands is clear, how did the erosion since 1942 affect the seagrasses colonizing the waters adjacent to Smith Island? A general look at the loss of land since 1942 and the loss of the submersed vegetation (Fig. 68) does not show a clear correlation between these two parameters. An example of this lack of correlation between coastal erosion and loss of seagrasses can be seen in the Tylerton area where relatively small areas of marsh were lost but the decline of seagrasses was relatively severe (Fig. 69). Another such example can be found in the Sheep Pen Gut area: although coastal erosion was not as severe as in the area adjacent to Chesapeake Bay, the loss of the vegetation was more severe in the protected area between the islands than in the highly exposed and eroded area (Fig. 70). This suggests that the loss of vegetation in these areas is not directly linked to coastal erosion. Only the

Shoreline in the Smith Island Area
1942 and current

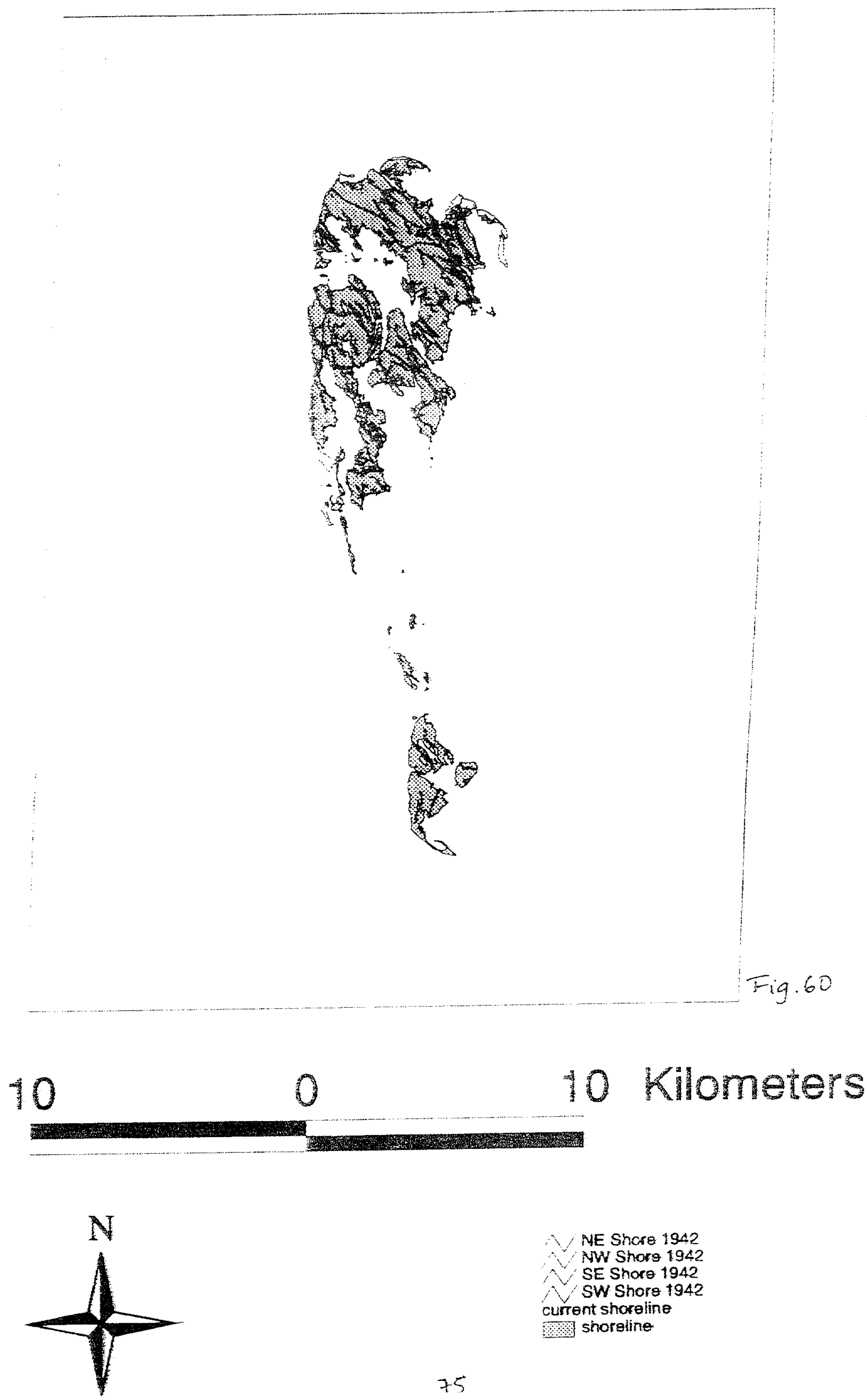


Fig. 60

Shoreline Change in the Maryland Portion of Smith Island from 1942 to the present

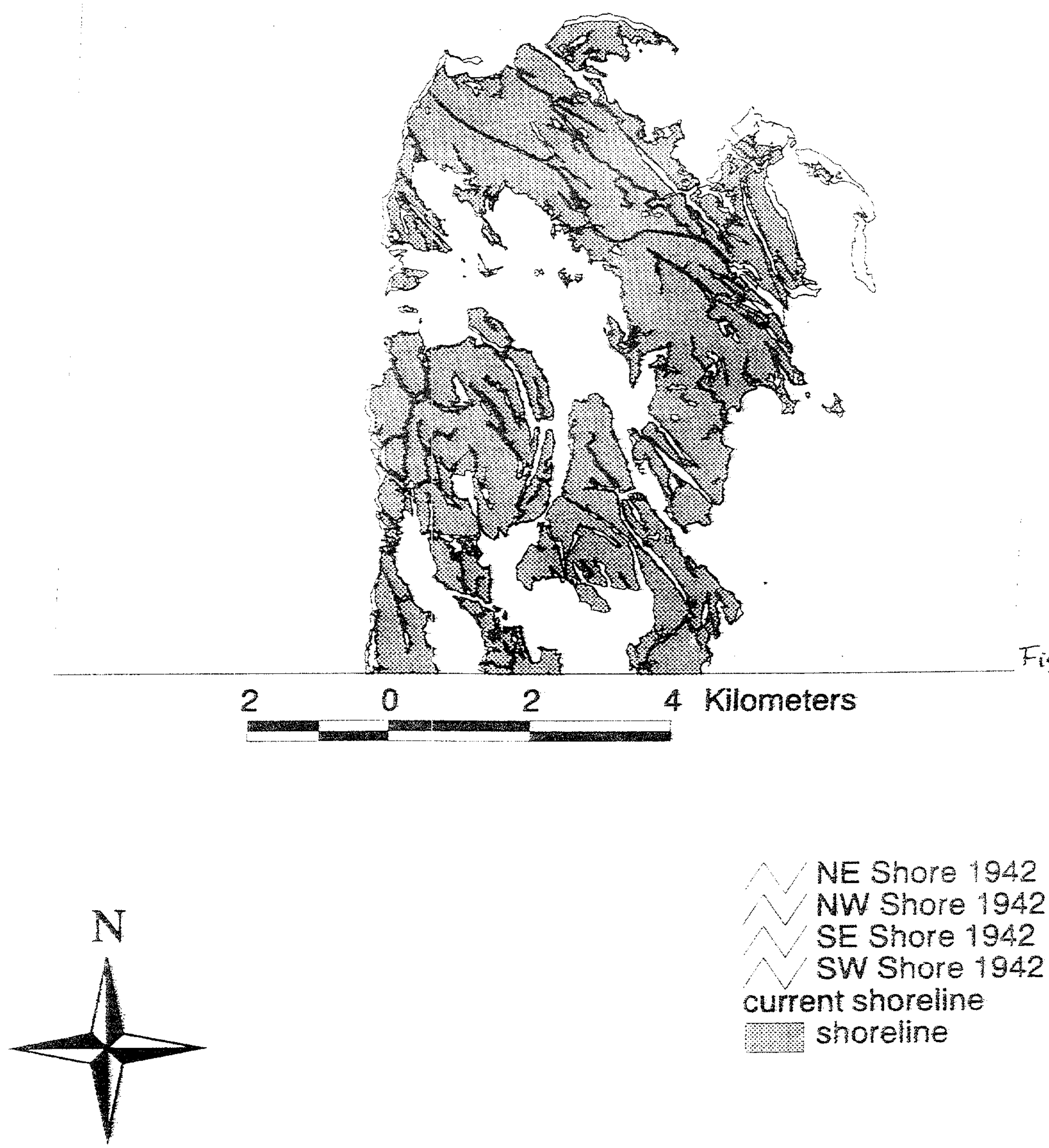
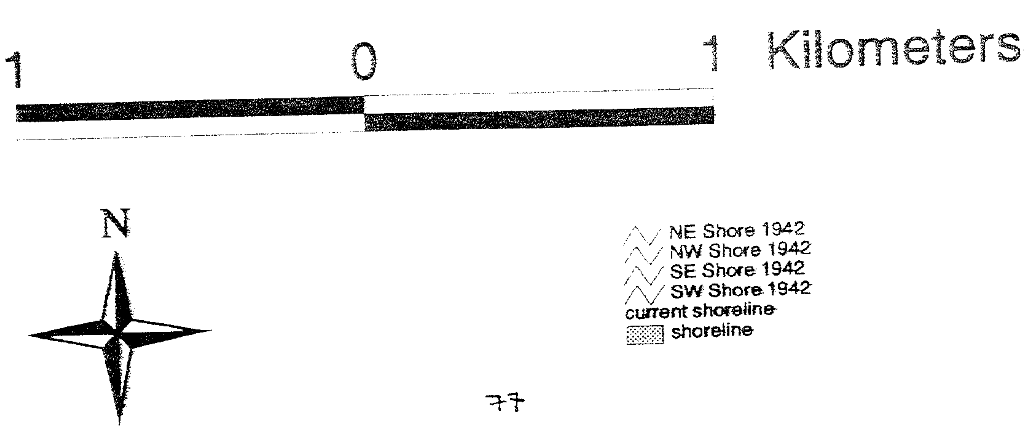


Fig. 61

Shoreline in the Tylerton Area
1942 and current

Fig. 62



Shoreline in the Sheep Pen Gut Area 1942 and current

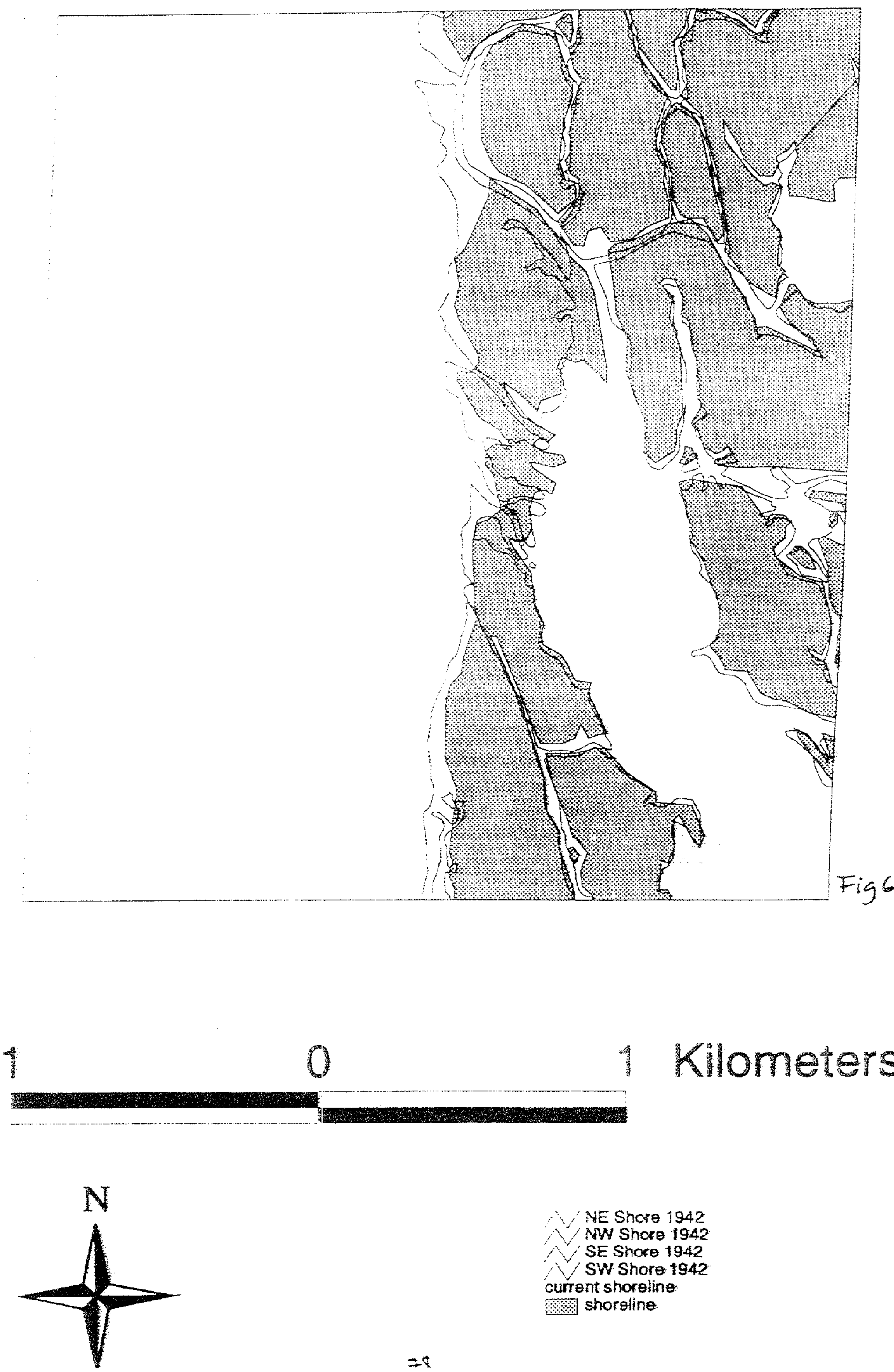


Fig 63

Shoreline in the Swan Island Area
1942 and current

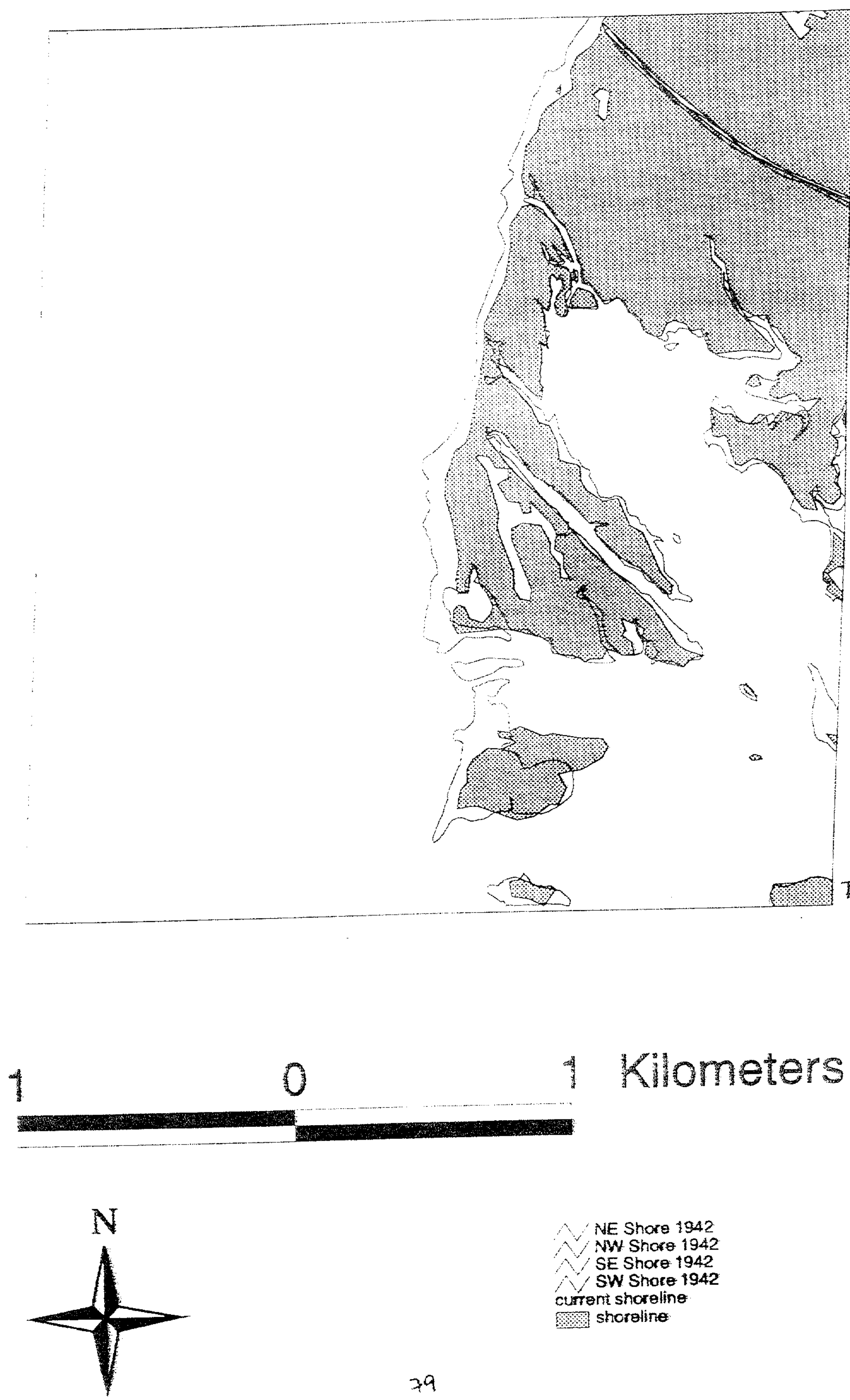


Fig 64

Shoreline in the Fog Point Cove Area
1942 and current

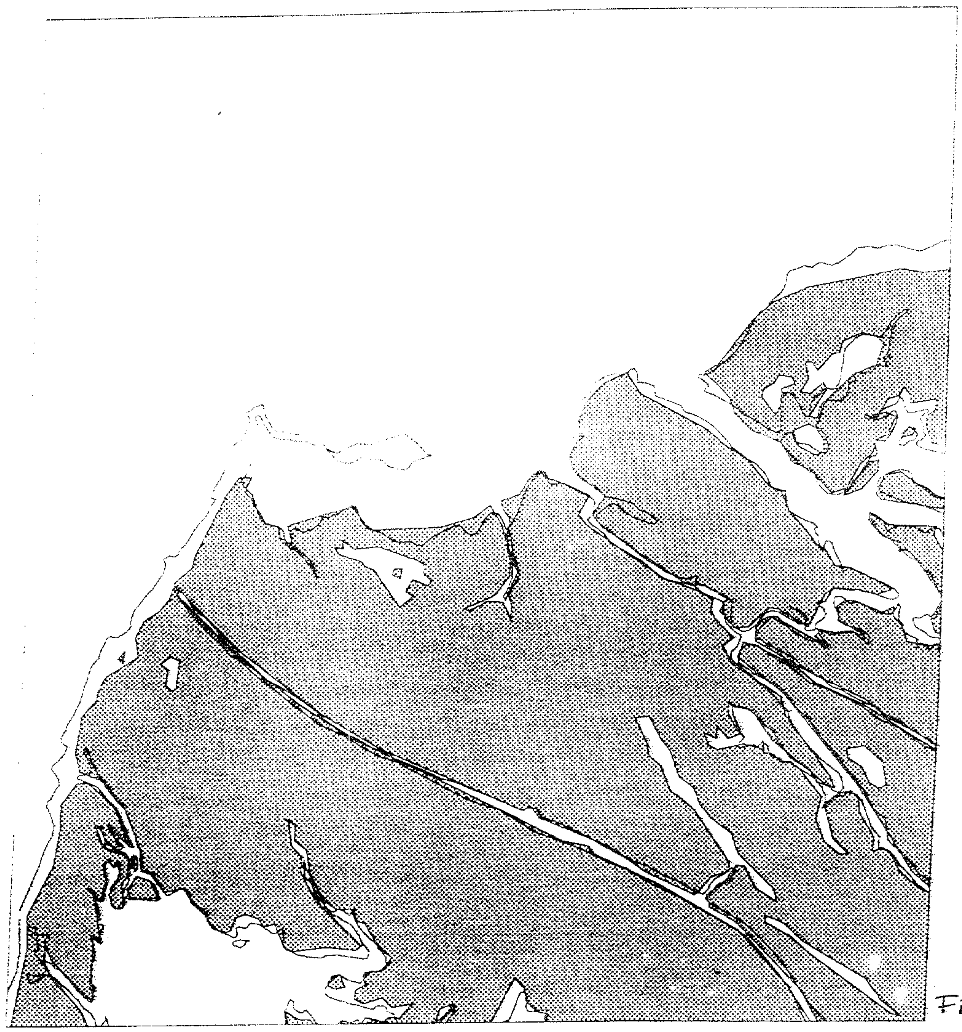


Fig 65

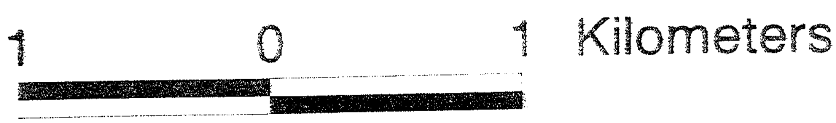
1 0 1 Kilometers

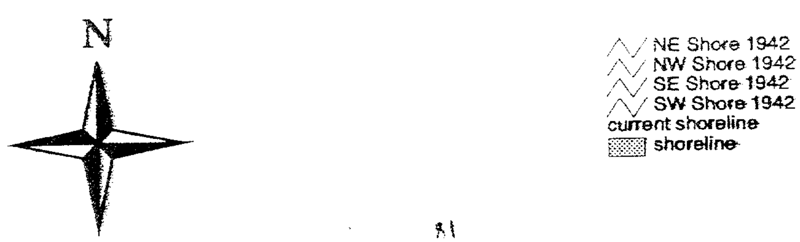
N

NE Shore 1942
NW Shore 1942
SE Shore 1942
SW Shore 1942
current shoreline
shoreline

Shoreline in the Back Cove Area
1942 and current

Fig 66





Shoreline in the Terrapin Sand Cove Area
1942 and current

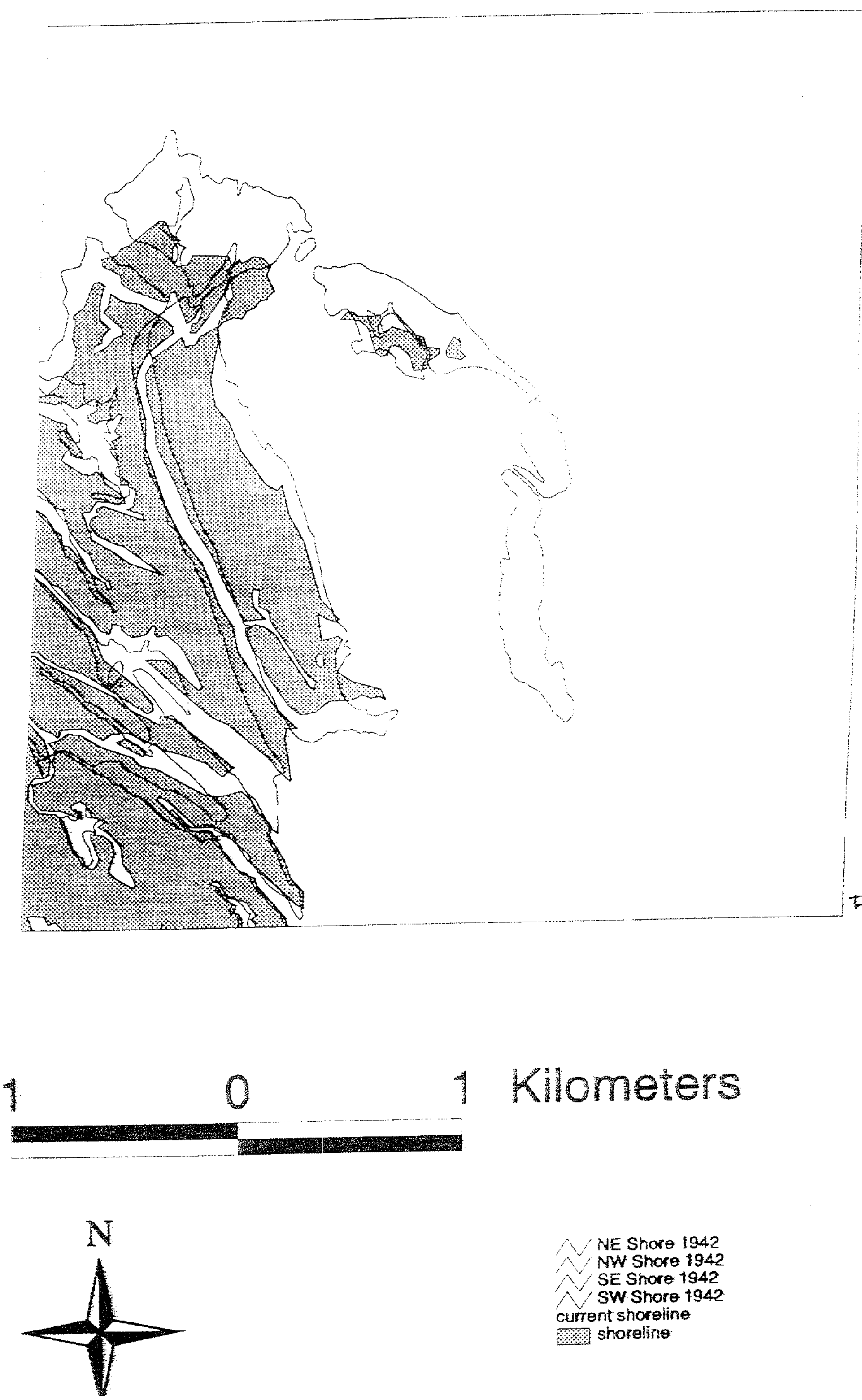


Fig. 67

SAV and Shoreline Change in the Smith Island Ar

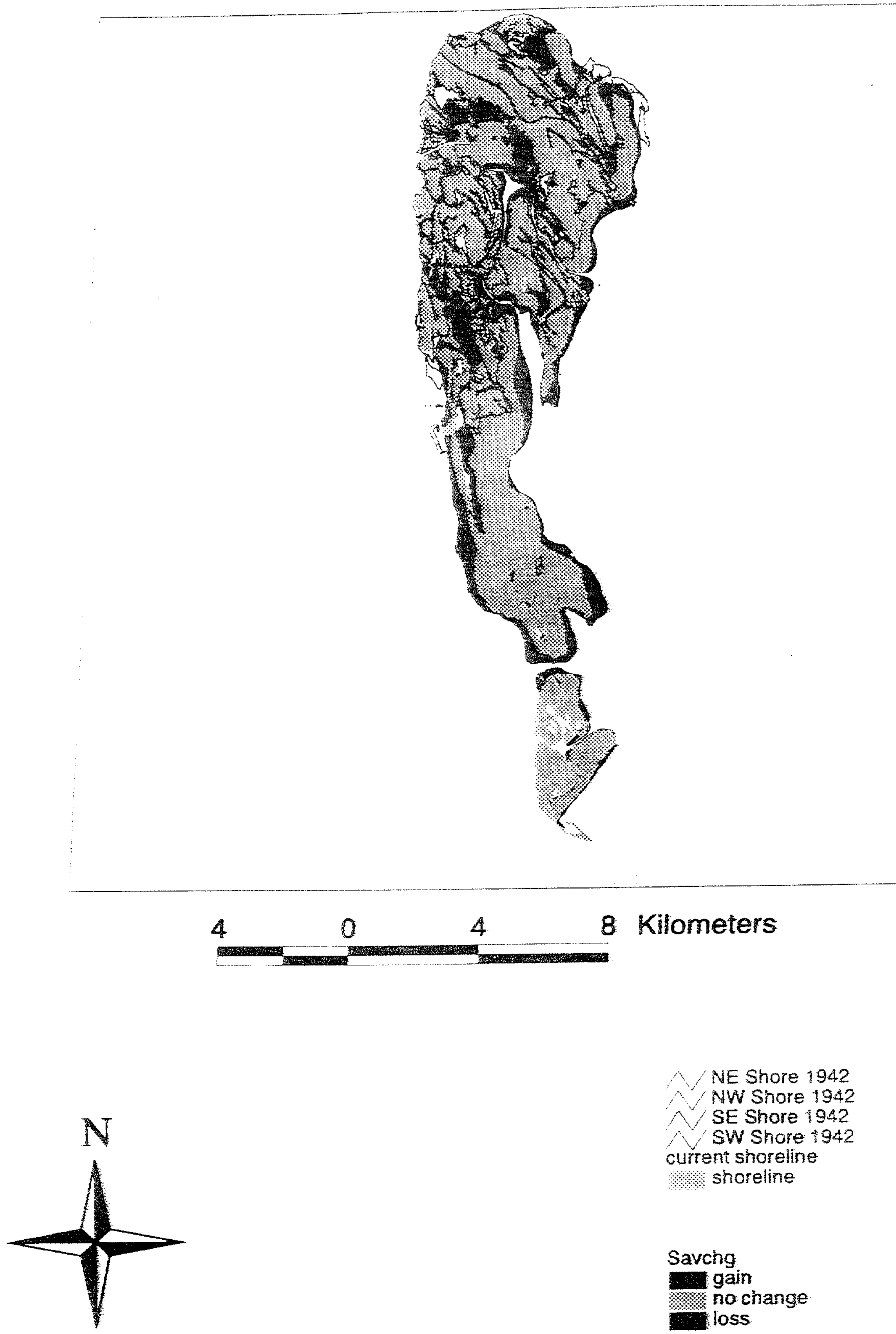
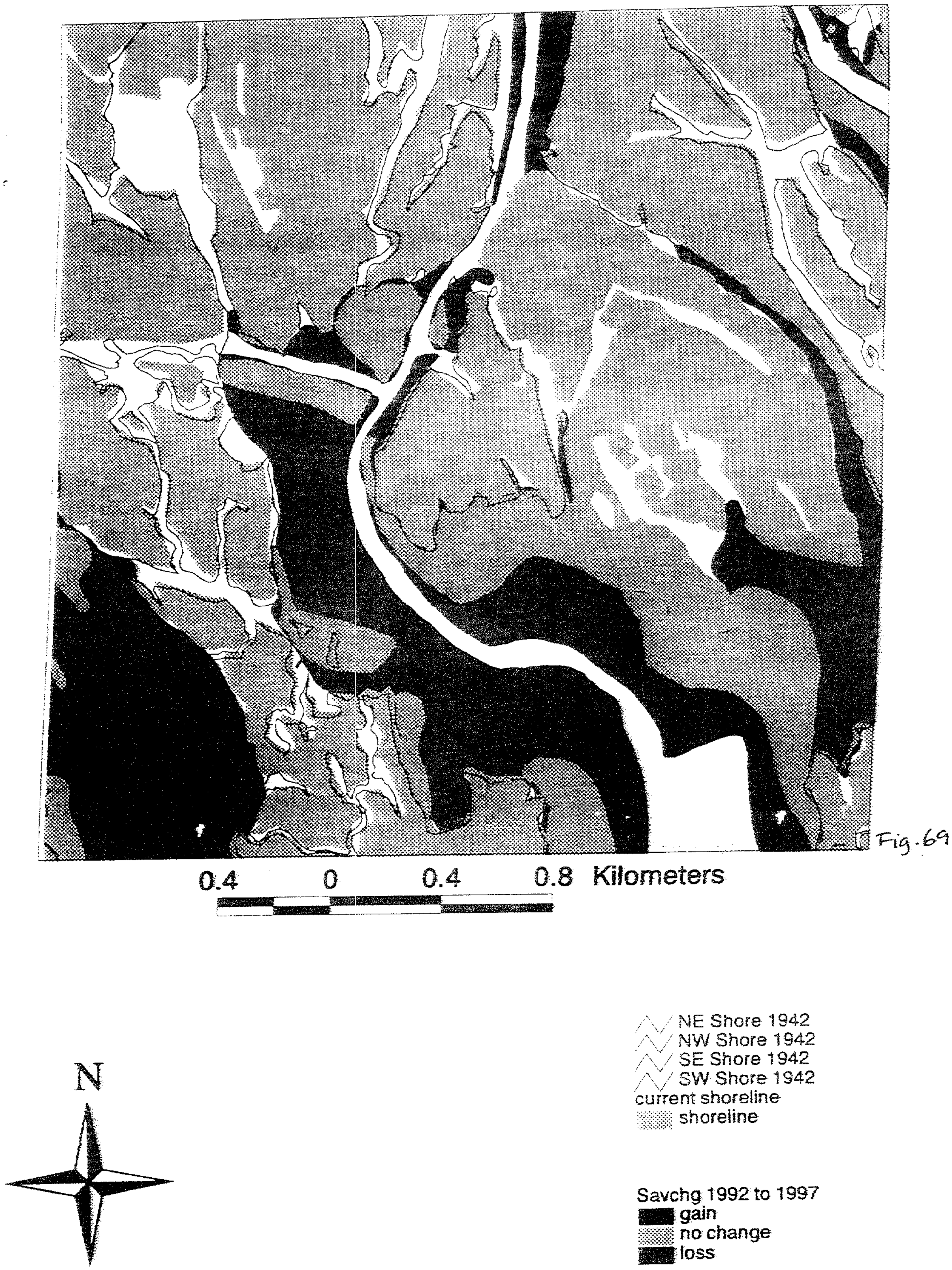


Fig. 68

SAV and Shoreline Change in the Tylerton Area



SAV and Shoreline Change in the Sheep Pen Gut Area

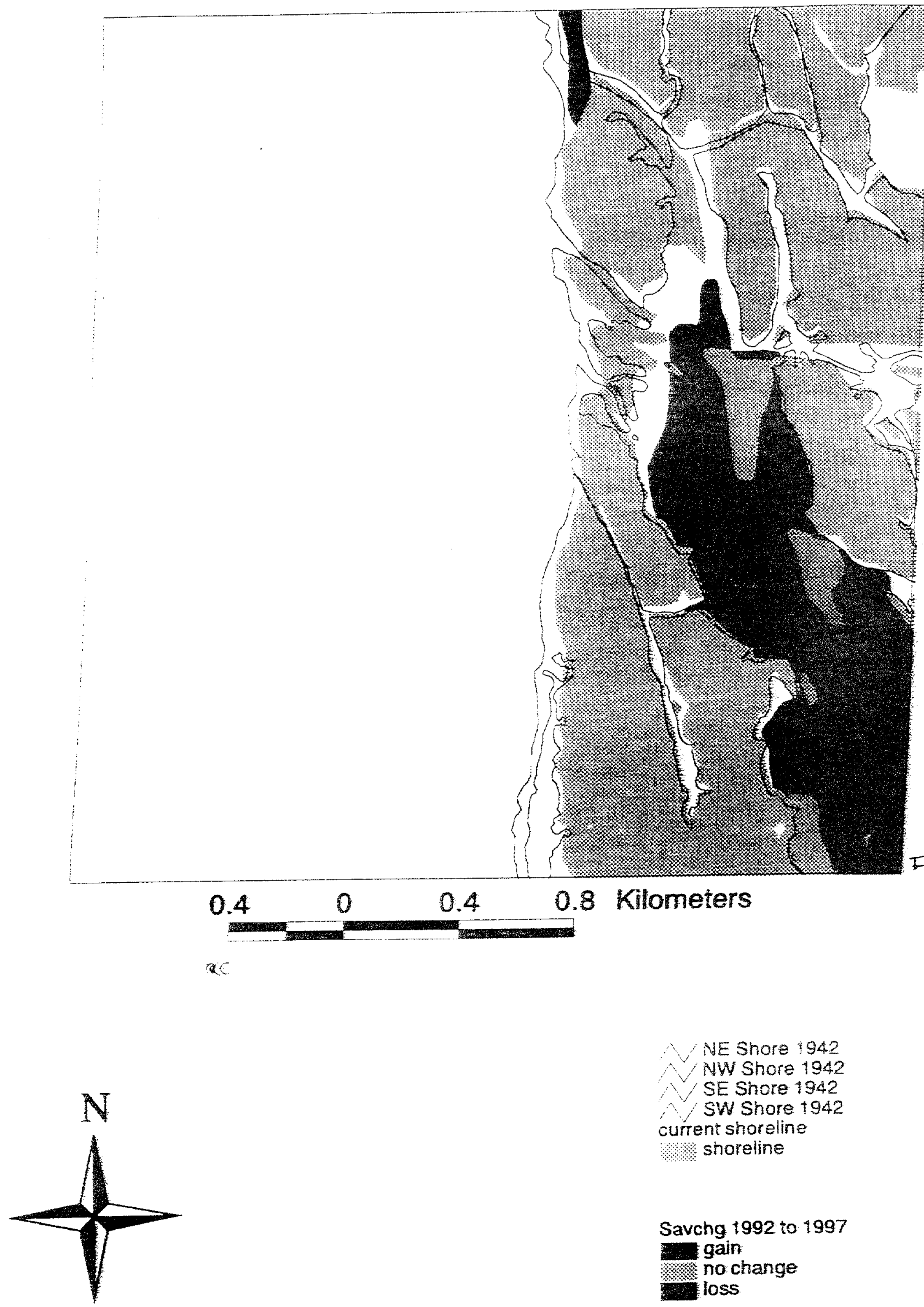


Fig. 70

loss of the seagrasses in the area north of the Gut (exposed to the Bay) which supported the growth of seagrasses in the past could be attributed directly to coastal erosion (a relatively small area when compared to the other areas in which seagrasses were lost). In the Swan Island area, the marshes north of Swan Island that eroded since 1942 actually provided new seagrass habitat (Fig. 71) but this is not the case for the marshes lost farther north, those directly exposed to Chesapeake Bay. The new habitat north of Swan Island is strongly linked to the sediment type that was eroded (coarser sediment than in marshes) (see "Sediment Characteristics" in the next section). The erosion of the peninsula protecting Fog Point Cove apparently also allowed for the development of new seagrass habitat as there has been an expansion of seagrasses into "deeper" areas (Fig. 72) when this is usually the area where seagrasses are lost. This gain of seagrasses offshore of the existing seagrass bed may be due to the accretion of sediment in an area which used to be too deep for SAV growth or may be due to the deposition of coarse sediment on top of fine sediment which is unsuitable for seagrass colonization. The answer could only be known through further studies of the area.

The loss of land and seagrasses in the Back Cove area do not correlate very well (Fig. 73) and the gain of seagrasses in the "deeper" area could be for the same reasons suggested for the gain offshore of Fog Point Cove but sediment data is needed to clarify this. In Terrapin Sand Cove, the loss of marsh islands offshore of the Cove seems to correlate with the loss of the vegetation (Fig. 74). In the areas where islands protected the seagrass bed (north and east of the seagrass bed), large losses in seagrass cover have been observed. Therefore, no generalization about coastal/marsh erosion and seagrass loss can be made for the Smith Island area. Each case needs to be evaluated separately. Some of the cases, especially that of Swan Island can be explained by the sediment characteristics in the area.

Sediment characteristics

Seagrass beds usually occur in areas where the sediments are relatively fine which is usually associated to relatively quiescent waters. Grain size does not seem to limit the growth of seagrasses per se but extremely fine sediments (cohesive sediments) do not allow the seeds to get buried. As a result, the seeds may be washed into areas that are too deep to support their growth after germination or may not provide the anoxic conditions that some seeds need to germinate (Koch in preparation). In contrast, sediment organic matter seems to be limiting to seagrass growth. Barko and Smart (1983) and Koch (unpublished data) concluded that the growth of seagrasses is limited to sediments containing less than 5 % organic matter. In a study done in the summer of 1998, it was found that sediments in seagrass habitats (less than 1 meter depth) in the Smith Island area are finer (Fig. 75) and have an organic content (Fig. 76) higher than that of other seagrass habitats in Chesapeake Bay. This could potentially limit the suitability of coastal waters adjacent to Smith Island to seagrass growth.

The reason for the higher organic levels in the sediments in the Smith Island area is that the marshes are eroding and the sediments which used to be marsh are now the sediments found in the seagrass habitats (areas less than 1 meter deep and adjacent to the eroding marshes). Marsh sediments are usually fine, often cohesive and with very high levels of organic matter. Such sediments are not suitable for seagrass growth. Therefore, in areas were marsh sediments are now the substrate for seagrasses, no seagrasses can be found. In contrast, in areas where other coarser sources of sediment cover the marsh

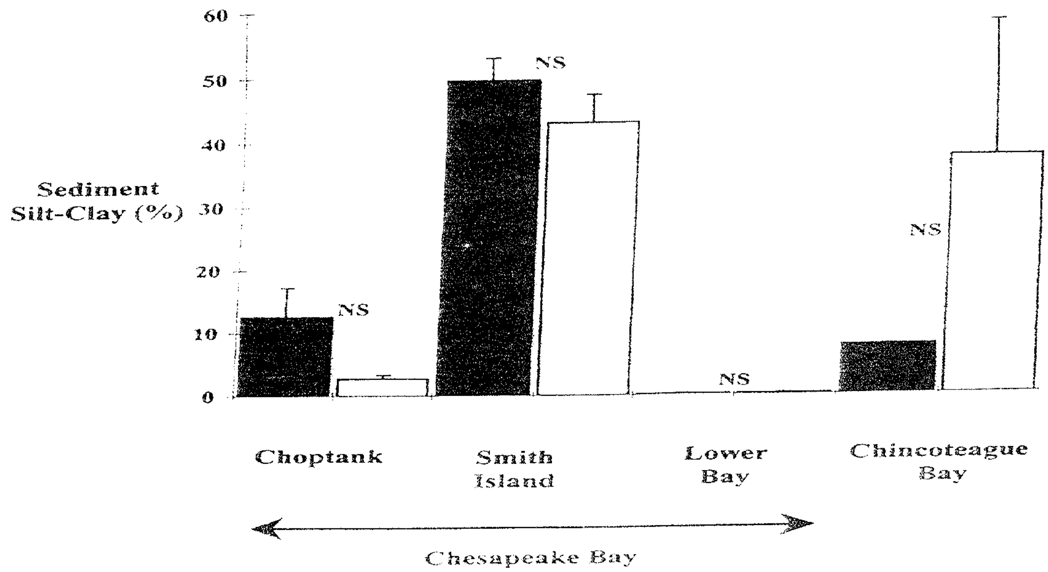


Figure 75. Percent silt and clay in sediments from vegetated (black) and unvegetated (white) seagrass habitats in Chesapeake and Chincoteague Bays. Note that the highest percentage of fine particles in a vegetated area were found adjacent to Smith Island.

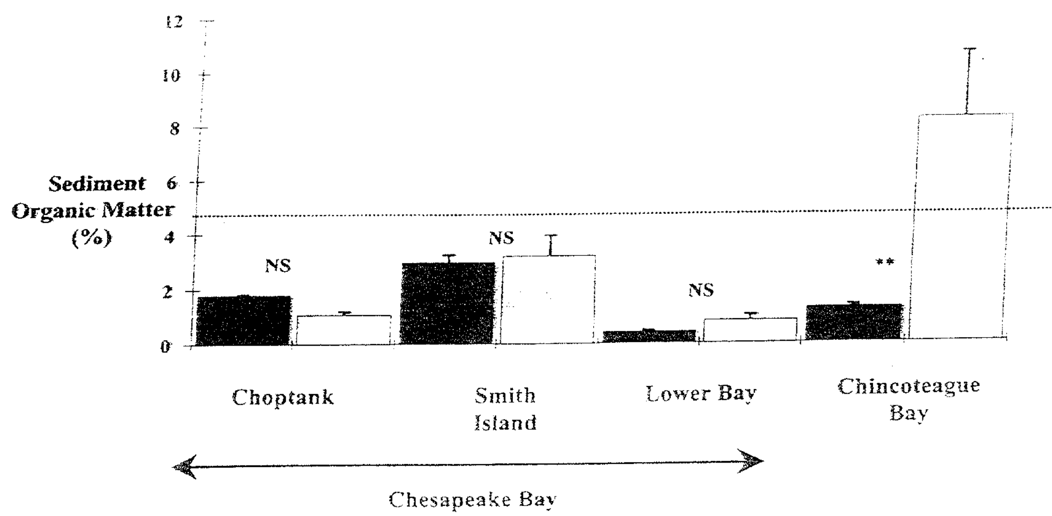


Figure 76. Percent organic matter in sediments from vegetated (black) and unvegetated (white) seagrass habitats in Chesapeake and Chincoteague Bays. Note that the highest percentage of organic matter in a vegetated area were found adjacent to Smith Island. The horizontal line indicates the maximum threshold for seagrass growth.

sediments, healthy seagrasses can be found even when wave energy is relatively high. This can be seen in the northeast portion of Smith Island where four sediment cores (2 inches in diameter) were collected on July 17, 1999 at a depth of approximately 1 meter (3 feet). The sites where the cores were collected ranged from Swan Island to the northeast portion of Smith Island.

The northern most sample (core #15) was 21 cm long. The top 2 cm consisted of medium sand with 0.62% organic matter) and overlayed what appears to be an eroded marsh (consolidated silt and clay with 7.56% organic matter) or even highland (protruding tree stumps) (Fig. 77). Core #3 (northern end of Silver Island) consisted of consolidated silt and clay (13 cm) with 5.52% organic matter (Fig. 78) suggesting that this area used to be a marsh that eroded over time and is now submersed. Core # 10 (offshore of the breach between Silver and Swan Islands) was 27 cm long and consisted exclusively of medium sand with 1.12% organic matter (Fig. 79). This area was colonized by sparse Ruppia maritima (Widgeon grass). The southern most sample (core # 16) consisted of a 11.5 cm layer of medium sand (1.2% organic matter) overlaying a mixture of sediments with particles ranging from silt/clay to coarse sand (Fig. 80). The high organic content (6.24%) of this sediment suggests that it may have originated from erosional marshes. This area was colonized by relatively dense Ruppia maritima (Widgeon grass). The source of the sand at this site could be from the eroding spoil on the island. It appears that the stone jetties adjacent to Swan Island may have facilitated the deposition of the coarser sediment.

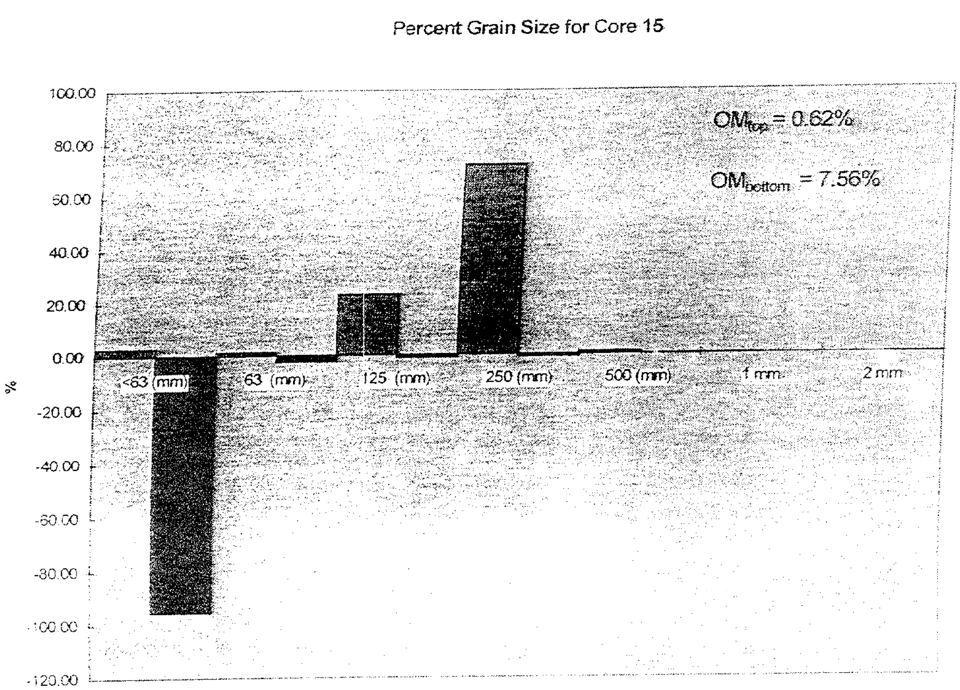


Figure 77. Sediment grains size distribution and organic matter content in the upper and lower layers of a sediment core collected in the waters adjacent to the northeastern portion of Smith Island.

Percent Grain Size for Core 3 (all mud)

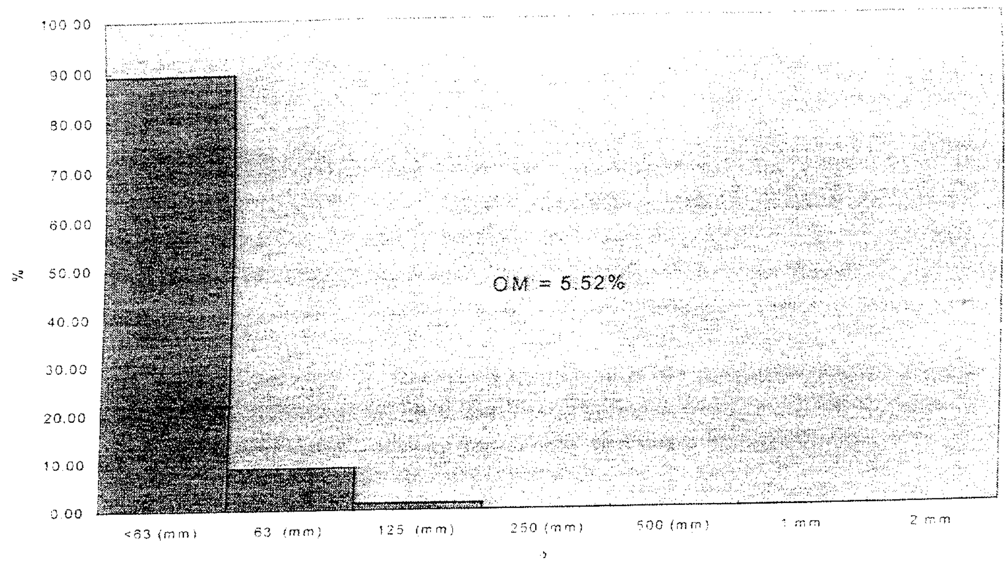


Figure 78. Sediment grain size distribution and organic matter content in a *sediment core collected in the waters adjacent to the northern end of Silver Island. This area was unvegetated.*

Percent Grain Size for Core 10

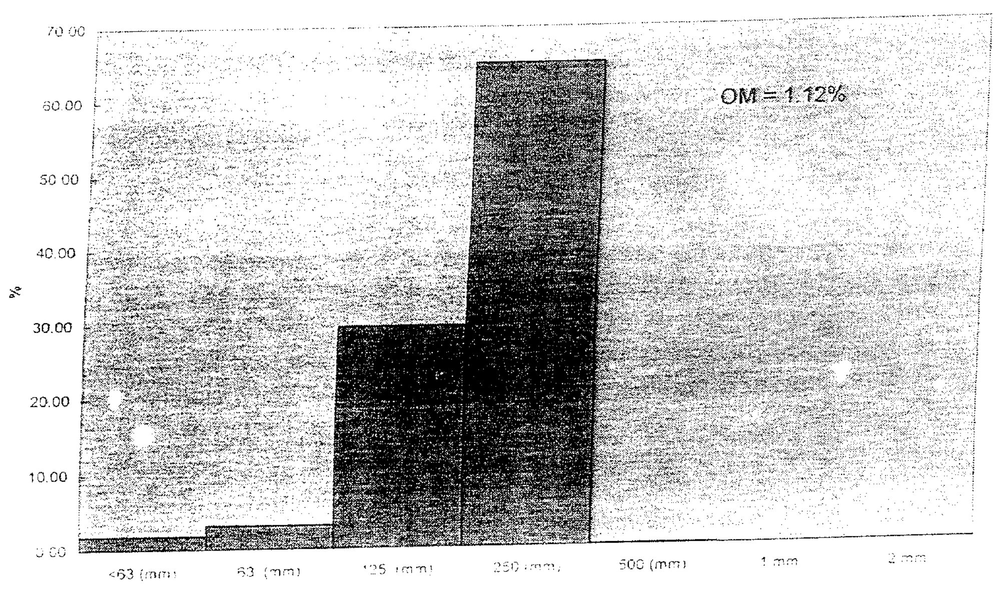


Figure 79. Sediment grain size distribution and organic matter content in a sediment core collected in the waters adjacent to the breach between Silver and Swan Islands. This area was vegetated.

SAV and Shoreline Change in the Swan Island Area

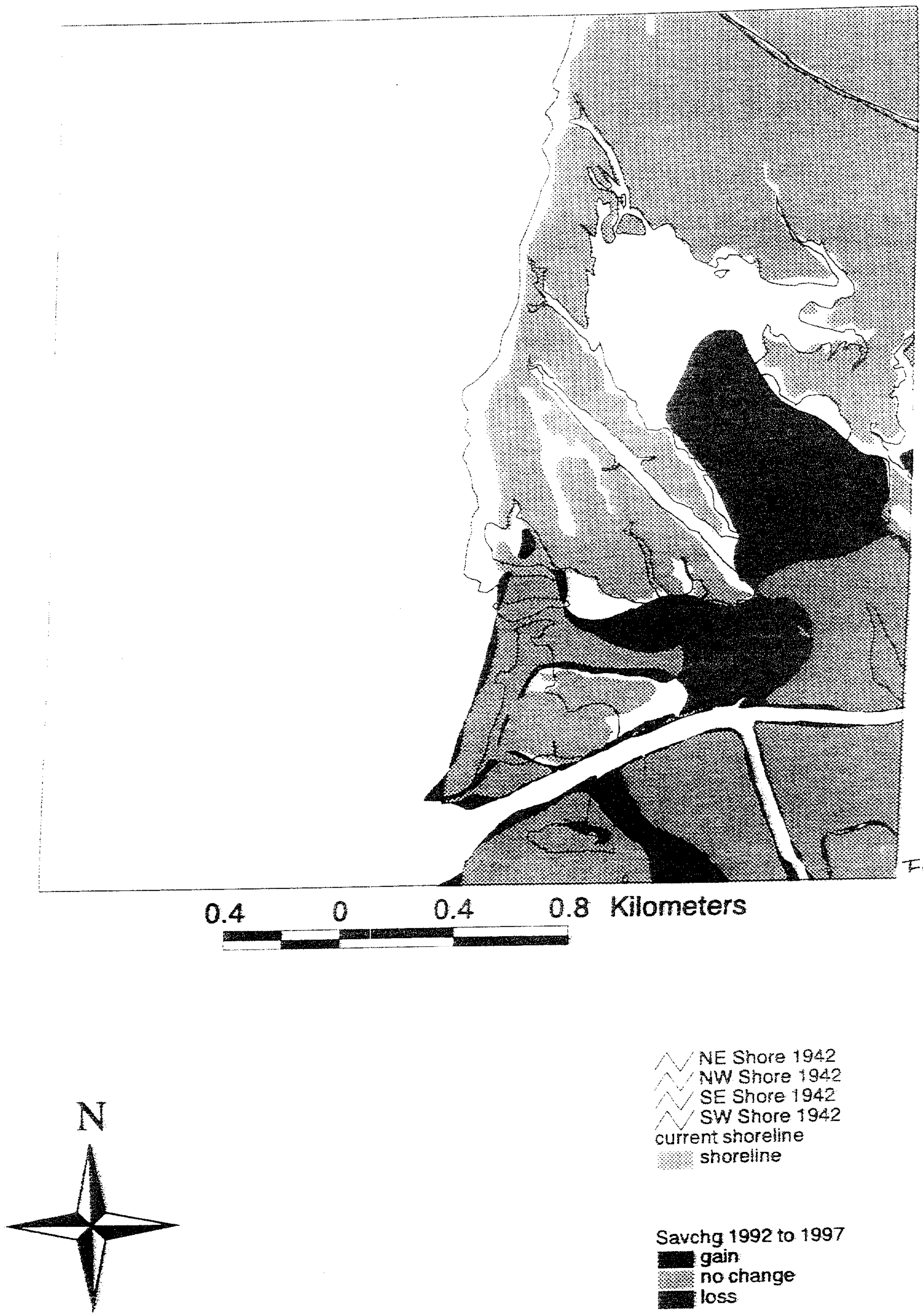


Fig. 71

SAV and Shoreline Change in the Fog Point Cove Area

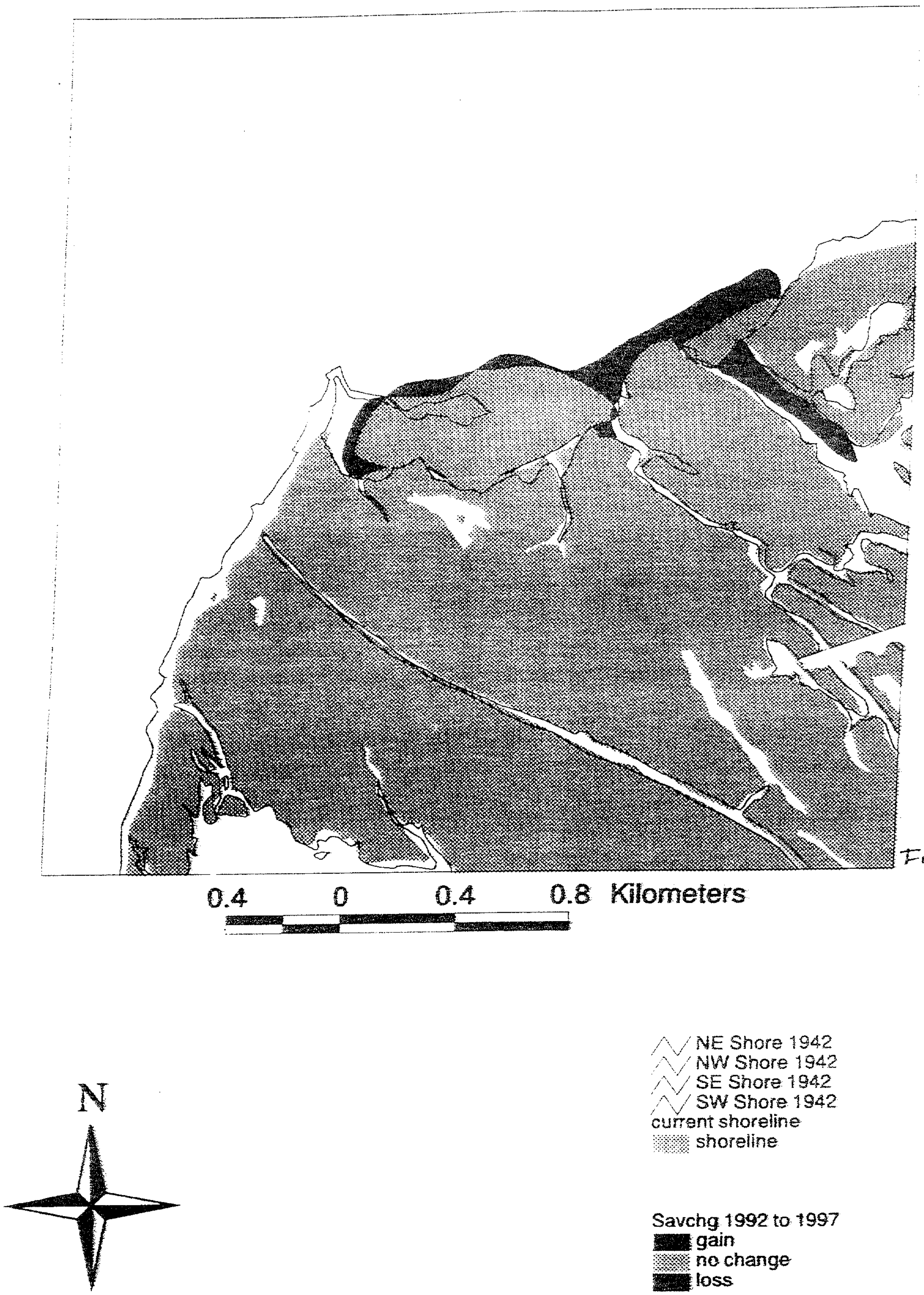


Fig. 72

SAV and Shoreline Change in the Back Cove Area

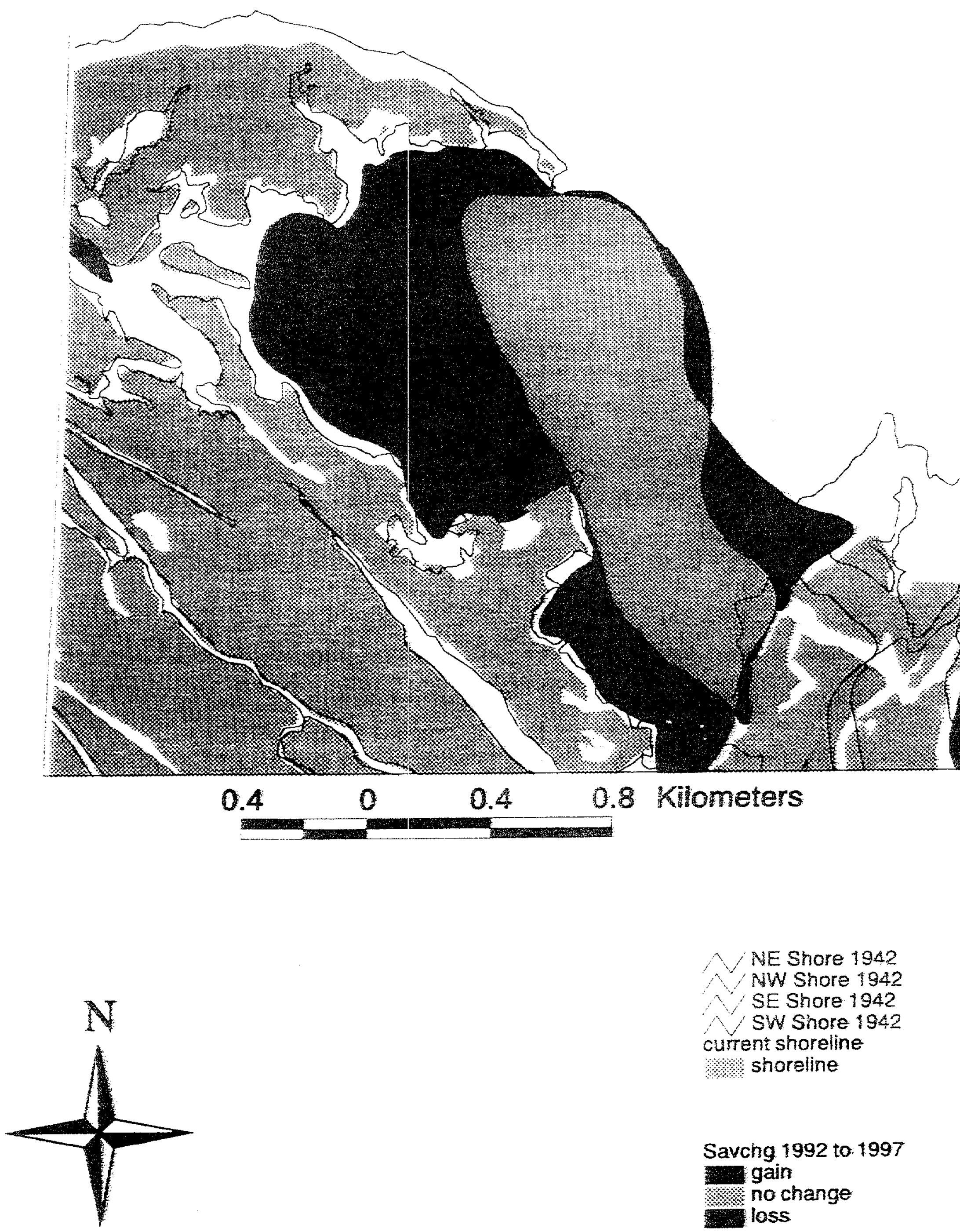


Fig. 73

SAV and Shoreline Change in the Terrapin Sand Cove Area

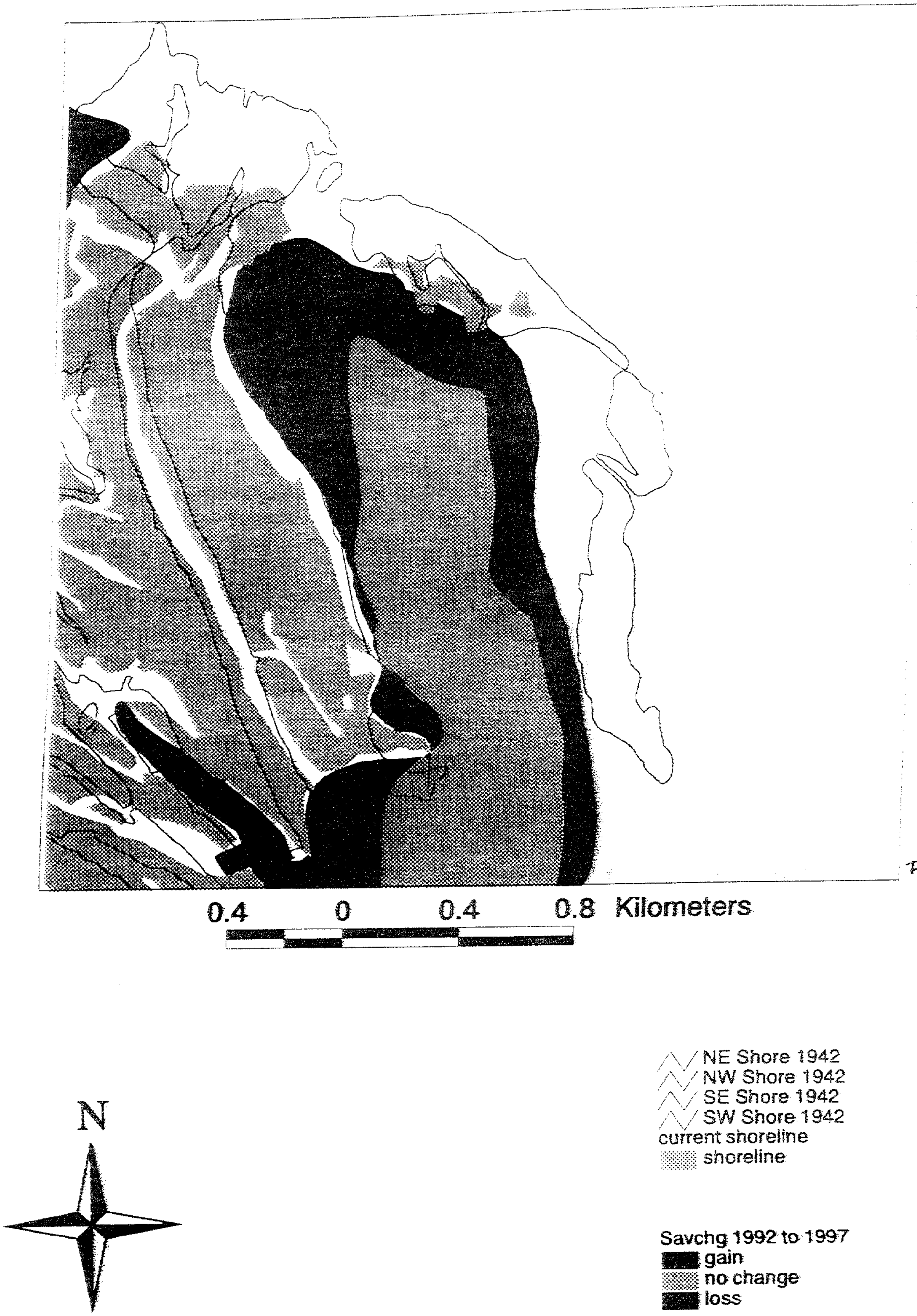
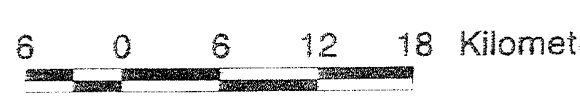


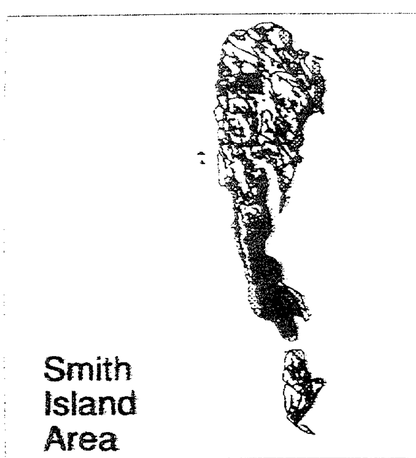
Fig. 74

Boat Scars in the Southern Portion of the Smith Island Area

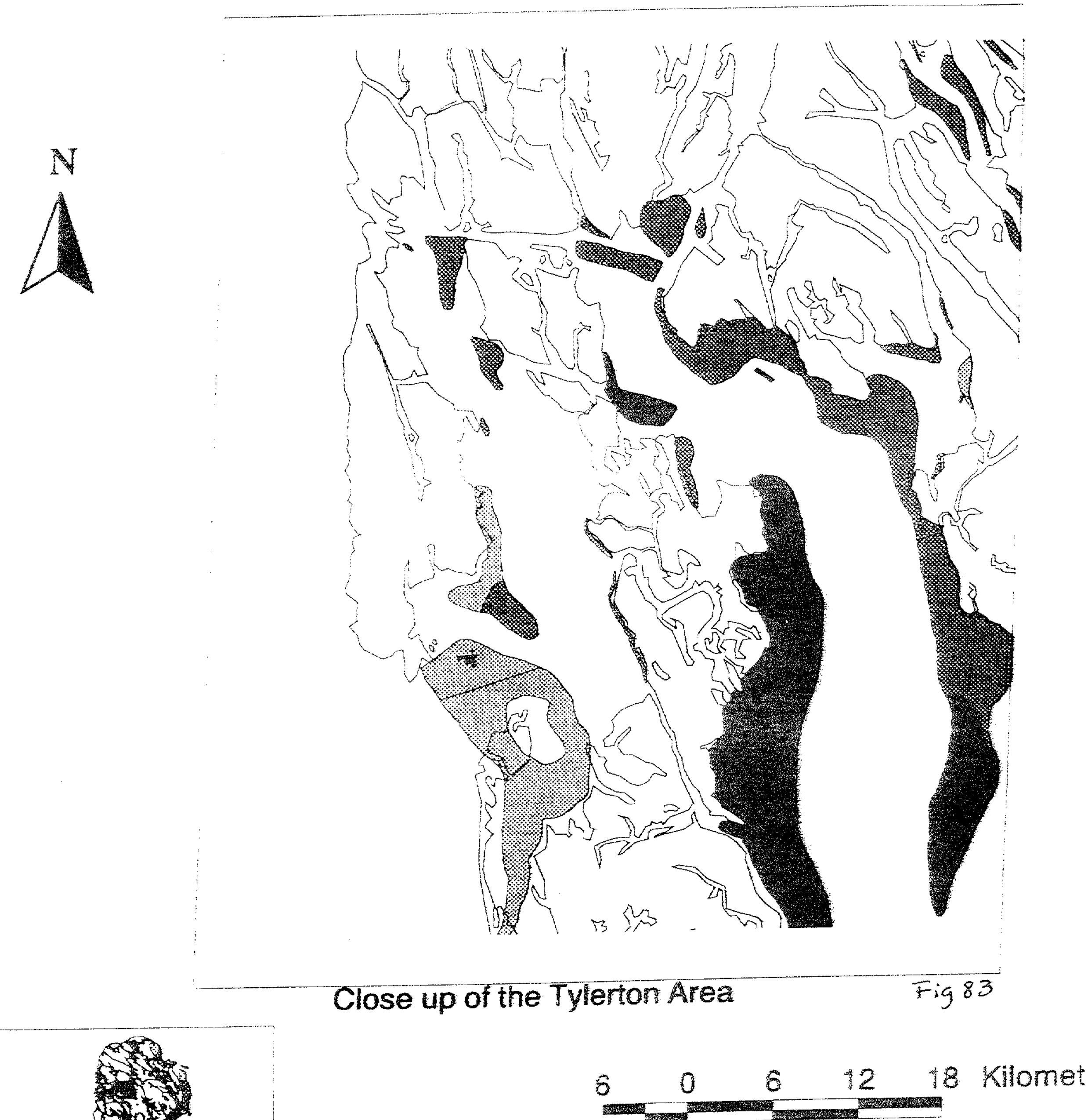
Close up of the Southern Portion

Fig. 82



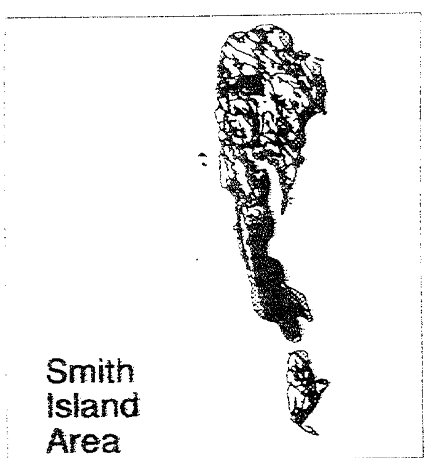


Boat Scars in the Tylerton Area



Close up of the Tylerton Area

Fig 83



Summary and Recommendations

The seagrasses around Smith Island have experienced a general decline in area covered, in the density of the beds as well as a shift in species distribution (from the climax species Zostera marina to a primary colonizer. Ruppia maritima). The cause for this shift in species is not well understood but could possibly be related to the stress that eutrophication imposes on these plant communities. This can only be confirmed with additional studies.

The general decline of seagrasses in the Smith Island area may be associated to increase suspended sediments in the water column. These sediment particles would be coming from marshes which are eroding horizontally as well as vertically due to accelerated sea-level rise. This is also only a hypothesis and needs further data to be proven. What can be said is that the vegetation covering most of the seagrass habitats adjacent to Smith Island (Ruppia maritima) has natural fluctuations in which it can completely disappears one year only to fully recover in one or two years. The causes for these fluctuations are also unknown. Therefore, it becomes difficult to predict the changes in seagrass distribution or to attribute these changes to environmental parameters.

Theoretically, all areas between the mean low water level and a 1 meter depth are suitable for seagrass growth. Most of the areas around Smith Island that fit these criteria are located between the smaller islands or on the east side of the island as well as in the northern coves. The western shore has less of such habitats but seagrasses can still be found in these areas but only where coarse sediment overlays the finer sediments originated from marsh erosion. Therefore, sediment composition seems to be essential for the suitability of an area for seagrass growth. Extensive areas of Smith Island, especially those on the western and northwestern shores are undergoing extensive erosion of the marshes that form the island. As these marshes erode, the fine sediments with very high organic content become the new substrate in the shallow seagrass habitats. As seagrasses can not colonize cohesive sediments, marsh erosion is leading to loss of seagrass habitats. In contrast, in areas where coarser sediments are being eroded, new seagrass habitats are being created (see Swan Island and Fog Point Cove). Therefore, the stabilization of rapidly eroding marshes may only be beneficial to seagrasses if coarse sediments will cover the eroded marshes that are now the seagrass habitats.

The recreation of the peninsula that semi-protected Fog Point Cove may not be cost-effective when it comes to the protection of seagrasses. Since the erosion of this peninsula, seagrasses have expanded into that area and now go beyond the area where the peninsula used to be located. Therefore, the submersed vegetation does not seem to be impacted by waves and may not benefit from a structure protecting the cove. In contrast, the marshes in that Cove are eroding and an artificial structure offshore of where the peninsula used to be located may reduce the erosion of the marshes in the back of that cove.

The loss of the islands and peninsulas offshore of Terrapin Sand Cove may have resulted in the partial loss of the vegetation. As a result, the construction of a protective structure may be beneficial to the submersed vegetation. Further studies would be required to prove this.

Coastal erosion is a large-scale process in the Smith Island area and may require extensive resources in order to improve the seagrass habitat. In contrast, there are also smaller scale issues that could be addressed to enhance the growth of seagrasses in the Smith Island area. For example, the lack of recovery of seagrasses in the area west of Tylerton, where most boat traffic occurs, may be related to the shading of the docs as well as the activity of the boats. While the boat traffic could not be stopped due to its economical impact, the docs could be redesigned to be more environmentally friendly. Extensive studies have determined that higher docs and docs with spaces between the wood beams on which one walks have less of an impact on the vegetation than the docs which exist in the area. Additionally, the watermen could be encouraged to move their "houses" into deeper areas (farther along the piers) where seagrasses would be less likely to be affected.

In summary, the Smith Island waters are very suitable for seagrass growth but the perimeter of the island is eroding at an accelerated rate which is changing the sediment characteristics of the seagrass habitats. This process can only be reversed by stabilizing the shoreline and depositing coarser sediment on top of the erosional marshes which now form the substrate for seagrasses.

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